Sustainable Supply Chain Management through the integration of IoT: Road Transportation

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Master’s dissertation 30 Credits
Spring 2022
Leadership for Sustainable Development: Master’s Programme, Business studies - P4322
Acknowledgement

I would like to acknowledge my supervisor Arash Kordestani for pointing me towards the right direction. Special thanks to all the teachers and the staff related to the Leadership for Sustainable Development: Master's programme; thank you for being there for us, guiding and educating us through a global pandemic.

It would not have been possible to complete the programme alone without the support and contribution of my classmates, so thank you, everyone, for being there for each other. Interviews taken for the dissertation were a great way to get to know some fantastic people to whom I will forever be thankful for their contribution. Finally, huge thanks go to my friends, family, and my girlfriend for their emotional support and constructive criticism.
Abstract

Traditional transport companies usually focus on achieving economies of scale in supply chain management. At the same time, the managers of transport companies aiming to achieve sustainability often do not consider the barriers needed to overcome to achieve a sustainable supply chain. However, due to the increasing demand for sustainable products and business methods, sustainable supply chain management increasingly plays a crucial role in changing and diverting the focus on environmental, social and economic impact. Transport companies around the globe are increasingly aiming to reduce carbon emissions and eliminate biodiversity loss. The sustainability issues with transport in supply chain management have been a critical field of research for decades, and with the integration of technology, new ways of achieving sustainability are possible. This thesis analyses a phenomenon using multiple cases to investigate the barriers transport companies face to adopting IoT. Also, it deals with how communication service providers might be able to offer solutions to the barriers presented in this thesis.

A qualitative method has been used to approach the research topic. The findings will represent the ways of achieving a more efficient and sustainable supply chain, particularly in the transport sector. Interviews were conducted with multiple industry experts. The study aims to identify the barriers to adopting IoT, which can create a sustainable supply chain for transport companies.

The results emphasise the barriers transport companies have to deal with internally and externally. Internally a company might struggle to strategise an infrastructural investment, train the existing workforce, and collaborate knowledge share among different departments. Externally, transport companies or communication service providers (CSP) will face limited resources, stakeholders' investment in the IoT ecosystem, demand for IoT and sustainable supply chain, privacy issues, compatibility issues and lack of skilled labour.

Keywords: Sustainability, sustainable development, Internet of things, road transport, road transportation, communication service provider, internal barrier, external barrier, facing and overcoming barriers.
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<tr>
<td>3TG</td>
<td>Tin, Tantalum, Tungsten and Gold</td>
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<tr>
<td>Ajot</td>
<td>American Journal of Transportation</td>
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<tr>
<td>BDA</td>
<td>Big Data Analytics</td>
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<tr>
<td>CPS</td>
<td>Cyber-Physical System</td>
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<td>CSP</td>
<td>Communication Service Provider</td>
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<tr>
<td>DDoS</td>
<td>Distributed Denial of Service</td>
</tr>
<tr>
<td>ERP</td>
<td>Enterprise Resource Software</td>
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<tr>
<td>ESG</td>
<td>Environmental, social, and corporate governance</td>
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<td>FSC</td>
<td>Forward Supply Chain</td>
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<td>FTL</td>
<td>Full-Truckload</td>
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<td>GDPR</td>
<td>General Data Protection Regulation</td>
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<td>GSCM</td>
<td>Green Supply Chain Management</td>
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<td>IS</td>
<td>Information System</td>
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<tr>
<td>ISS</td>
<td>Institutional Shareholder Services</td>
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<tr>
<td>IIoT</td>
<td>Industrial Internet of Things</td>
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<td>IoT</td>
<td>Internet of Things</td>
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<tr>
<td>IT</td>
<td>Information Technology</td>
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<tr>
<td>LTL</td>
<td>Less-than-truckload</td>
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<tr>
<td>MIT</td>
<td>Massachusetts Institute of Technology</td>
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<tr>
<td>MSCI</td>
<td>Morgan Stanley Capital International</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<td>OTR</td>
<td>Over the road</td>
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<td>PTL</td>
<td>Partial-Truckload</td>
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<td>RFID</td>
<td>Radio Frequency Identification</td>
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<td>ROI</td>
<td>Return on Investment</td>
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<td>RSC</td>
<td>Reverse Supply Chain</td>
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<td>SC</td>
<td>Supply Chain</td>
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<td>Supply Chain Analytics</td>
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<td>Supply Chain Management</td>
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<td>Supply Chain Network</td>
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<tr>
<td>SDG</td>
<td>Sustainable Development Goal</td>
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<td>SSCM</td>
<td>Sustainable Supply Chain Management</td>
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<tr>
<td>SMEs</td>
<td>Small and Medium Enterprises</td>
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<tr>
<td>SVAT</td>
<td>Sustainable Value Analysis Tool</td>
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<tr>
<td>TBL</td>
<td>Triple Bottom Line</td>
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<tr>
<td>TEN-T</td>
<td>Trans-European Transport Network</td>
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<tr>
<td>UTAUT</td>
<td>Unified Theory of Acceptance and Use of Technology</td>
</tr>
<tr>
<td>VUCA</td>
<td>Volatility, Uncertainty, Complexity, and Ambiguity</td>
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1. Introduction

This chapter provides the background information and the definitions of IoT, Supply chain management, and Industry 4.0. The aim and objective, along with the research questions, are covered in this chapter.

1.1 Background

As far as history goes, Egyptians built Pyramids, the industrial revolutions, world wars, humanitarian crises, and SARS-CoV-2 took place; supply chain management (SCM) has been the most influential factor in managing the right resources at the right place and at the right time. Since the term was coined in the 1980s, it was quickly adopted as a critical part of the business. With rapid globalisation expansion and industrial shift from Industry 3.0 to Industry 4.0, which refers to Industry Internet of things (IIoT), enterprises can make data-driven decisions much faster to address VUCA (volatility, uncertainty, complexity, and ambiguity). Even with the rapid shift towards IoT, many industries remain hesitant due to cyber security risks, inability to adapt to changes, higher integration costs, and various critical issues. Those making the first move of merging IoT in supply chain processes get extensive visibility, agility, and adaptability to cope with SCM challenges (Ben-Daya, Hassini, and Bahroun, 2017). IoT enables rapidly improving business performance and aligning business value to the landscape environment changes of this century. It also brings cost-saving, inventory accuracy, and product tracking by aiding SCM to be more efficient and effective. IoT has opened up a whole ecosystem of interconnected devices, including phones, sensors, smart speakers, cars connected to smart grids, and businesses to a massively automated supply chain (Greengard, 2021).

1.1.1 IoT

The Internet of Things (IoT) is a dynamic, interconnected global network infrastructure. It allows devices and data to be a part of a small or a large ecosystem. IoT is not a single technology; instead, it is an innovative collection of several technologies complementing to bridge the
distance between the digital and physical world (de Vass, Shee and Miah, 2021). IoT was first termed in 1999 by a group at the Massachusetts Institute of Technology (MIT). Ever since then, the ‘Thing’ in IoT, which was considered a process of tracking items via the internet, has evolved and broadened to include many digital devices such as Radio-frequency identification (RFID), sensors, actuators, smartphones and smart items, and so forth (de Vass, Shee and Miah, 2021). These devices can give organisations the ability to identify uniquely, read, sense, locate, address and control functions of their supply chain remotely via the Internet (de Vass, Shee and Miah, 2021). Market research firm ‘IoT Analytics’ predicts that more than 21.5 billion IoT devices will exist by 2025 (Greengard, 2021). This revolution of an interconnected industry took off when the introduction of the iPhone took place back in 2007; that is when the masses had access to data and could real-time connect to other devices through a palm device. This phenomenon ignited the concept of interconnected devices in a global framework of computation, storage, and communication (Greengard, 2021). IoT, an emerging technology, offers potential solutions for innovation and a new approach to operation, manufacturing, supply chain, and logistics (Manavalan and Jayakrishna, 2019). The term IoT first appeared when RFID sensor tags were first used worldwide; RFID tags were first commonly used by Proctor and Gamble’s supply chain (Ben-Daya, Hassini, and Bahroun, 2017). RFID is a tag sensor that uses radiofrequency to search, track and communicate with people and items. IoT is being adopted by organisations worldwide as a step to get digitised and enter the ecosystem of shared data. The impact of COVID-19 pushed the increased use of IoT sensors as more organisations, governments, and people began to adapt to digitalisation. Online shopping became a more significant trend, boosting the global adaption of IoT in the supply chain (McKinsey & Company, 2021). IoT has a wide range of applications. It is used in smart factories, enables governments and organisations to build smart cities, and is used in cars, logistics, manufacturing, and even health care. The military uses IoT for many applications, such as defensive measures, tracking assets, etc. Long before, IoT applications such as smart homes, supply chain technology, and intelligent transportation were limited by industry or individual organisations (Jiang, 2019). With the wide adaptation of IoT, shared intelligence among various users of such systems worldwide can produce a good cluster effect within diverse industries (Jiang, 2019).
1.1.2 Supply Chain Management

The supply chain is a vital part of modern businesses; organisations, governments and the military all rely upon the complex supply chain of this century. It is a system of connected networks, from the procurement of raw materials to the delivery of the end product to the customers. According to Ruston et al. (2017), these business activities are commonly known as value chains involving the flow of physical information and storage from one stakeholder through the logistics networks to the other. As Svensson (2002) argues, SCM is a philosophy for businesses that concurrently should address the overall bi-directional dependencies of all actors, activities, and resources in all operational, tactical and strategic levels, from the point of beginning to the end customer and also in between channels. Supply chain activities vary from industry to industry. However, the most common involve demand and supplies planning, procurement, product lifecycle management, supply chain planning (including inventory planning and the maintenance of enterprise assets and production lines), logistics (including transportation and fleet management), and order management (Oracle.com, 2020). Sustainable supply chain management (SSCM) has three key goals of social, environmental, and economic performance; by attaining the three goals, enterprises try to fulfil customer requirements by managing the SC processes in an efficient manner, such as the flow of materials, services, information, value-add, and money in both forward and reverse direction (Robertson, 2021).

1.1.3 Industry 4.0

As the name suggests, there were four stages of the Industrial Revolution; the term Industry 4.0 was coined in Germany in 2011. The first stage was the usage of hydropower or steam engines to improve the performance of manufacturing. The second stage was the introduction of electricity which increased production volume, and the third stage, known as the digital revolution, started in the late 1990s. Digital Revolution is known for the spread of automation, the internet’s invention, the usage of nuclear power, and digitisation. Industry 4.0, the fourth stage of the Industrial Revolution, came into existence due to an interconnected global network through which decentralised data transfer is possible. This was possible for the booming cellphone industry, cloud storage, and the continuous improvement of Intelligent information systems. Industry 4.0 will slowly bring forth the factors of the physical world and digital system interaction factors more efficiently into a reality (Wollschlaeger, Sauter and Jasperneite, 2017)
and make operations more sustainable than ever before. This can only be achieved if enterprises and governments collaboratively move towards the transformative adaptation of digital technology (Liao et al., 2017). Industry 4.0 is a relatively new word circulating among academia and the digitalised industries. The reason behind including such a descriptive introduction of Industry 4.0 in this thesis is to give a general idea to the readers about the meaning of this concept.

1.1.4 Road Transportation

Transportation plays an integrative role in supply chain structure, as firms strategically use transportation to maximise customer value (Morash and Clinton, 1997). There are four significant transportation categories: road, rail, marine and air. However, for this thesis, we will focus on road transportation as it is the most vital form of transportation in the supply chain. Road transport such as city trucks, Line-Haul (40-foot and 53-foot trailers), and Special Vehicles (e.g. livestock containers, automobile carriers, and tankers.) can access places where other modes of transportation are limited by their structure (Blume Global, 2018). In the U.S. alone, road transportation carries freight worth more than fifty billion dollars daily, making it the most significant source of carbon emission producer in the supply chain. There is a massive emphasis on the decarbonising transport sector. Even though road freight transportation is continuously adopting sustainable practices, according to Furtado (2018), there is still a long way to go from an overall implementation of sustainability measures in the transport sector. To meet the essentials of a sustainable approach, transport companies have to take into consideration a variety of social, economic, and environmental indicators: labor, profit, energy consumption, pollution, etc. (Krishnan, 2013).

1.1.5 Sustainable Supply Chain Management

Sustainability became a topic of discussion and practice worldwide when the Brundtland Commission of the United Nations defined sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987). Aligning with the original definition of sustainable development, the UN global compact (2015) in their report defined “Supply chain sustainability” as the management
of environmental, social and economic impacts and the encouragement of good governance practices throughout the lifecycles of goods and services. Seuring and Müller (2008) also define sustainable supply chain management as “the management of material, information, and capital flows, as well as cooperation among companies along the supply chain, while taking goals from all three dimensions of sustainable development into account”. Therefore, SSCM involves the wider set of performance objectives identified by the TBL approach - economic, environmental, and social (Seuring and Müller, 2008; Carter and Easton, 2011; Meixell and Luoma, 2015). According to the UN global compact (2015), the goal of a sustainable supply chain is to create, protect and grow long-term economic, environmental, and social for all stakeholders involved in bringing products and services to market. Through sustainable supply chain management, transport companies or any other company involved with the supply chain can protect the long-term viability of their business and secure a social license to operate (UN global compact, 2015). Linton et al. (2007) argue that to achieve SSCM, the environmentally friendly procedure should be used in each part of the supply chain, including transporting goods among manufacturers, suppliers and customers. Transportation being the largest source of environmental pollution in the supply chain, proper transportation and logistics system design would positively impact SSCM performance improvement (Ji, Wu and Zhu, 2016).
1.2 Problematisation

As stated above, IoT is a technological platform with the potential to increase productivity, efficiency and profitability using predictive analysis and big data technologies (Kamble et al., 2019). IoT can improve efficiency and gain sustainability for road transport companies, but road transport companies are still lagging in adopting and implementing IoT. Saarikko et al. (2017) argue that many still consider IoT a novelty, and delays in widespread adoption occur for barriers such as high costs, lack of knowledge and unsuitable infrastructure. There are numerous other challenges for road transportation, such as scalability, security issues, heterogeneity, architecture, and the adoption of IoT technologies (Sharma et al., 2020). Organisations are often pressured by competition and are obliged to implement IoT to copy competitors rather than fully understanding and utilising the potential of IoT (Noronha, Moriarty, O’Connell, & Villa, 2014; Saarikko et al., 2017; Uckelmann et al., 2018). There has been a considerable discussion on the delay of IoT adoption (Hwang, Kim and Rho, 2016). With the rapid growth of IoT production, no industry is excluded from its impact, though the retail industry uses IoT in a broader application (Pantano et al., 2018; Pantano and Timmermans, 2014). However, the future projection shows that IoT adoption will be an enabler of the transition to a sustainable transport system (Melander, Dubois, Hedvall, & Lind, 2019; von der Gracht & Darkow, 2016) and the key to information sharing between different transport network actors (Harris, Wang, & Wang, 2015).

There is a gap in research on the barriers of IoT in road transportation and how it can lead to a sustainable supply chain. Research on the adoption barriers has been done in industries such as the food industry (Kamble et al., 2019), waste management (Sharma et al., 2020), end-user (Padyab et al., 2019), medicine, FMCG supply chains (Končar et al., 2020), agriculture and smart farming (Madushanki et al., 2019; Gaspar et al., 2021), and intermodal transportation (Altuntaş Vural et al., 2020). Implementing IoT in road transport requires a holistic approach to understanding the barriers by considering all the internal and external factors involved. Few studies have taken a holistic approach to understanding overall supply chain management's barriers (Cui et al., 2020; Hwang, Kim and Rho, 2016). IoT is an ecosystem of devices that impacts every industry; the barriers faced by the different industries can be adaptable for research purposes in the transport industry. These barriers work as a framework for data collection and discussion. This study will shed light on the context of IoT in road transportation
and help bridge the research gap on IoT implementation in the road transport industry. There is a need to understand and research why there are barriers to digital tools integration in the road transport supply chain, specifically on the Internet of Things.

1.3 Research aim and research questions

This study aims to identify the barriers surrounding the road transport industry in adopting technology like IoT devices. That is why a case study of the phenomena is being done to understand how to overcome IoT barriers and the benefits involved for organisations. Multiple industry experts complement the research with their knowledge of the supply chain and IoT. Thus, this study is a phenomenon where multiple barriers to IoT implementation in road transport companies are explored. The study will first explore the previous research with an in-depth understanding of the sustainable supply chain and the phenomenon surrounding it, and then it will lead to IoT. The literature will end with the barriers identified through previous works on different industries. The topic is further characterised by the following research questions-

1. What barriers do road transportation companies face while integrating IoT to achieve Sustainable Supply Chain Management (SSCM)?
2. How do road transport companies overcome the barriers?

1.4 Conceptual Framework

The primary topic of this thesis is to study the phenomena of barriers that road transport companies face while adopting IoT in their supply chain. As mentioned in the problematisation section of previous research, multiple barriers have been identified fitting to the road transport industry. This research examines the current barriers in different industries and then aligns them to similar barriers in the road transport industry. Along the way, this research, through literature review, introduces sustainable supply chain management (SSCM) and the role IoT plays in SSCM and road transportation. The barriers examined in this research are limited resources, Infrastructure, Investment, Security, privacy, seamless integration, compatibility, legal/accountability, lack of skilled labour, and scalability. Providing a conceptual framework for
this research seemed fitting as Miles and Huberman (1994) describes a conceptual framework “lays out the key factors, constructs, or variables, and presumes relationships among them”. Conceptual frameworks often bring ideas from outside the traditionally defined field of study or integrate different approaches, lines of investigation, or theories that no one had connected before (Maxwell, 2013). There is existing research on the barriers to supply chain digitisation and also barriers to ICT implementation in supply chain and transportation; IoT implementation has also been discussed and researched in different industries involved with the supply chain. This thesis presents the barriers to IoT implementation in road transport companies, and according to Maxwell (2013), barriers from different industries have been adapted to connect the barriers faced by road transport companies in this research. A conceptual framework for research is usually constructed, it incorporates pieces that are borrowed from elsewhere, but the structure and overall coherence are something the author builds (Maxwell, 2013).

Figure 1: Conceptual Framework
1.5 Scope and Delimitations

Implementing IoT to achieve a sustainable supply chain requires a holistic approach, as many industries still operate traditionally. It will require strategic decisions and drastic infrastructure investments to adopt IoT for sustainable supply chain management, specifically for the transport sector, where sustainability issues are in the limelight. The technology implementation is not always sustainable, referring to hardware production, electricity consumption and deforestation for biofuel. However, it enables data collection, leading to sustainable decision-making. This thesis investigates the road transport companies' barriers to adapting IoT to achieve a sustainable supply chain. This thesis studies the phenomenon of the multiple barriers to implementing IoT. After identifying the barriers, reasonable ways to overcome these barriers by transport companies will be presented in this thesis. Since transport companies differ based on their operation and geographical location, some of the barriers illustrated might not be fitting for all companies and may therefore be left with uncertainty on overcoming these barriers.
1.6 Research Paper Structure

The diagram below shows the research paper is structured -

![Research Paper Structure Diagram]

1.7 Thesis Contribution

The thesis study contributes to a broader sustainable supply chain management field, IoT and Road Transportation. It integrates the three research fields and provides insights to explore what barriers road transportation companies are currently facing in integrating the existing Internet of things (IoT) technology which can provide them with a sustainable practice approach in their supply chain. Future research can extend upon the current barriers found in this thesis. As technology shifts toward Industry 4.0, innovations in road transport will appear, which means new barriers to implementing IoT might appear and might eliminate the current barriers found in
this thesis. The thesis facilitates a better understanding of the SSCM and barriers to IoT implementation by presenting an elaborate discussion on the basic functionality of SSCM and IoT, and by synthesising a huge volume of literature on both SSCM and IoT. The thesis study is relevant to practitioners in supply chain management and road transportation dealing with adopting innovative technology.
2. Literature Review

This chapter presents the theoretical reasons for adopting IoT for a sustainable supply chain in road transportation. Previous research and scientific theories relevant to the subject are presented in this chapter. The chapter will end with a section summarising the whole literature.

2.1 Background

The first and the last mile in the supply chain is usually done by road transport. Since the term logistics was introduced back in the 1970s, the production of materials has scattered so much geographically that it spiked the demand for road transport worldwide (EEA, 2019; Sierpiński and Staniek, 2019). With the evolution of technology and economic development, the solution to provide faster, just-in-time delivery seemed optimal during industrialisation without considering the multiple sustainability issues attached to global transport (EEA, 2019). According to the report of EEA (2019) and Kalevi Dieke et al. (2019), B2C E-Commerce is giving the platform of transportation a rapid rise as within the European Union (EU) member states, the revenue of e-commerce doubled from 2013 to 2017. With the rapid increase of transportation for faster delivery both upstream and downstream, it is crucial to raise the awareness of how it is sustainable since traditional supply chain managers only focus on efficiency and cost reduction rather than a sustainable or green approach towards transport (Meyer, Gracht and Hartmann, 2021).

2.2 Sustainable Supply Chain Management

According to Bui et al., (2021), SCM refers to the management of materials, information and capital flow, as well as collaboration and cooperation among the supply chain (sc) partners, like stakeholders and customers. While implementing all sustainable development goals initiatives from the triple bottom line (TBL) as economic, social and environmental dimensions. SSCM involves the wider set of performance objectives identified by the TBL approach by ensuring certain procedures are followed (Seuring and Müller, 2008b; Carter and Easton, 2011; Meixell and Luoma, 2015). Un Global Compact (2021) explains that supply chain sustainability is the
management of environmental, social and economic impacts and the encouragement of good governance practices throughout the lifecycles of goods and services.

Supply Chain is a network of upstream and downstream companies or individuals providing the end-users with valuable products and services; the supply chain connects all the consumers, suppliers and manufacturers (Dutta and Hora, 2017). These days organisations face the dilemma of choosing the best approaches to adopt sustainable development (Chen and Kitsis, 2017). Sustainable supply chain management ensures successful product manufacturing and delivery and can reduce supply chain waste, such as overall costs and material waste. The company's position in the supply chain plays a more significant role in adopting SSCM. Lo (2013) wrote that downstream companies usually adopt eco-design, green purchasing and internal environmental management practices, whereas those at the centre of the supply chain typically adopt sustainable manufacturing and sustainable logistics practices (Seles et al., 2016).

2.2.1 Supply chain disruption

Businesses trying to expand their global reach, using sustainable practices throughout their supply chain, gives them a competitive advantage. But the benefits come at a risk of SC disruption. SC disruption has been the mainstream of this century; from 2010 to 2020 was a period of substantial economic, political, social and environmental change (Robertson, 2021). With the continuous pandemic, wars and sanctions, organisations worldwide face supply chain disruption worldwide in every country they are operating. Sustainably procuring materials by keeping scores of labour and green practices of suppliers is a real challenge during disruptions. Global disruptions shifted SCM priorities; according to Robertson (2021), these shifts of the last decade are-

- SC security and resilience due to increasing threats.
- Customer service performance has been an essential focus with much faster delivery at a low cost.
- Bringing new products into the market more quickly and reliably than in the first decade of this century.
- Minimisation of carbon footprint, complying with government restrictions and Sustainable development Goals (SDGs) inclusion have become important throughout SCM.
- Technological innovation has been a visible drive, such as IoT, Big Data Analytics (BDA), Supply Chain Analytics (SCA), data mining, blockchain, Industry 4.0, digital supply chain and cloud computing.
- Supplier performance has been a critical issue with high volatile material prices.
- SC partner collaboration, SC cost competitiveness and productivity importance.

The priority of such a shift in the supply chain is often highlighted when significant crises like the financial crisis, the 2011 Japan earthquake, the recently recorded tsunamis, and the 2020 Sars-Cov-2 pandemic occurred. Nonetheless, the current economic sanctions of global power and wars in certain countries are likely to play a significant role in the SC disruption of this decade. Such disorders can have severe consequences if enterprises can not address them adequately at the right time; SC disruptions have become a critical issue for academics and practitioners (Bui et al., 2021). External events combined with the vulnerability of supply chain networks can cause a significant global systemic disruption (World Economic Forum, 2012). A survey by the World Economic Forum (2012) divides global disruptions into four categories, Environmental, Geopolitical, Economic and Technological. Figure 3 shows the triggers for global supply chain disruptions, and the events are categorised as uncontrollable, influenceable and controllable. Natural phenomena are usually out of human control, and the rest of the events can be forecasted or, in some ways, predictable. The supply chain can find solutions around such shocks to avoid supply chain disruptions (Lund et al., 2020).
Moreover, cyberattacks are one of the prominent threats that can cause severe supply chain disruption. Due to increasing cyberattacks through interconnected devices in the supply chain, adequate security measures must be taken to prevent such cataclysms. Organisations must ensure that data collected from sensors and various IoT devices must transfer to the central database through a secure channel and that those data are not being misused internally and externally. Such steps require management to decide quickly on information technology security, operational technology security and physical information security in an unprecedented way (Chen, Chen and Yang, 2021). Stakeholders also have to decide and determine the future of such
technology on who should regulate, operate and manage this data flow from IoT devices. The security challenges of IoT technology are one of the numerous reasons why many organisations find it challenging to integrate IoT into their supply chain. Disruption can also occur when the global interconnected IoT infrastructure in service gets vulnerable to cyber attacks. The distributed denial of service (DDoS) attack of 2016 was a perfect example of such turmoil. IoT is an ecosystem of heterogeneous devices where various devices communicate using multiple networks, making them vulnerable to threats such as denial of service (DoS), among many other viruses or hackers aiming to penetrate the devices for surveillance (Najmi et al., 2021).

2.2.2 Green Supply Chain Management

Green supply chain management (GSCM) is similar to the definitions of SSCM, emphasising more on eco-friendly concerns of inter-organisational supply chain management practices (Seles et al., 2016). Through evidence, the practices carried out in GSCM involve adopting internal environmental management, green purchasing, cooperation with the customer to meet their demand for green product purchase, investment recovery, eco-design and green reverse logistics1 (Seles et al., 2016). Actions regarding GSCM are usually taken when faced with environmental pressure through normative and coercive means; according to Seles et al. (2016), companies pursue GSCM facing the stress of multiple stakeholders, which include regulatory bodies, governments, customers, and suppliers, both upstream and downstream and contractors. To influence the adoption of green supply chain management, primary stakeholders often use the mechanism of regulations, audits, demand for green products, clauses in contracts and embargoes.

2.2.3 Green bullwhip effect

The bullwhip effect is a popular term in management, associated with excess production/order due to demand distortion, which travels upstream (Wang and Disney, 2016). The costs of bullwhip can be associated with the holding of excess inventory, unstable relationships among suppliers, idle machines, higher turnover rate, systems nervousness and many other challenges (Wang and Disney, 2016). The green bullwhip effect is similar to the bullwhip effect, with

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1 Green reverse logistics- The activities such as reuse, recycling, and remanufacturing, which are part of reverse logistics, are recognised as the function of green supply chain management. These shared functions of green supply chain management and reverse logistics embody what may be termed green reverse logistics (Hazen et al., 2012).
slightly different variations where customers and firms set indirect regulations of sustainable approach upstream. In the form of specifications, customers' requirements become even tighter upstream in the green bullwhip effect (Lee et al., 2014). Lee and Whang (2000) summarised that the bullwhip effect could be mitigated by sharing information among the supply chain. The typical schemes identified by Lee and Whang (2000) are sharing information on inventory level, sales data, sales forecast, order status, and production/delivery status both upstream and downstream. This information sharing can be done faster with IoT devices and cloud computing, leading to more accurate forecasting, sending out smaller batches, shortening the lead time, and reducing the bullwhip effect. Jiang (2019) further argues that efficient collaboration among the whole supply chain can be achieved among suppliers starting from raw material extraction to the delivery to the end customer. He further adds that it can be achieved through information exchange using IoT to increase coordination, inevitably reducing the impact of the bullwhip effect through the supply chain. Jiang (2019), in his paper, also analyses the cause of the bullwhip effect in the supply chain, and figure 4 represents the causes introduced by him.

Implementing a sustainable supply chain is bound to create a bullwhip effect. Because the dynamic decision involved in an environmental performance approach is a collaboration among all stakeholders, where the decision of supply chain members can generate a coordination risk that inevitably leads to instabilities among the supply chain (Lee et al., 2014). The classic bullwhip effect is usually described as demand-driven, whereas Lee et al. (2014) describe the green bullwhip effect as an event-driven change such as new environmental regulations, the industry responds to a negative occurrence or increase of customer awareness in carbon footprint and sustainable approach. The green bullwhip effect could have positive results in the supply chain if the company in focus provides environmental training and shared technologies to suppliers to reduce environmental pressure while achieving a sustainable supply chain (Seles et al., 2016).
2.2.4 Sustainable Road Transportation

Road transport is one of the vital components of economic development, trade, global connectivity and social integration. Growth in all types of transportation comes at the cost of biodiversity loss, greenhouse gas emissions, safety issues and exploitation of limited raw materials for production (Shen et al., 2011). Road freight transportation is a large source of carbon emission in the atmosphere; Furtado (2017) expects that carbon emissions will increase from 3.2Gt in 2015 to 5.7Gt in 2050 for road freight transportation.

Sustainable development is the most crucial objective for the EU; sustainable road transportation plays a vital role which cannot be overseen, where environmental pollution, energy consumption and road crash are the three fundamental challenges (Shen et al., 2011). One of the most significant barriers is the decarbonisation of transportation, as the demand for transportation is closely related to developing Gross Domestic Product (GDP) and evolves based on the transformation of economies worldwide (Meyer, Gracht and Hartmann, 2021). The concept of sustainability in road freight transport refers to the triple bottom line, where it considers the perspective of decarbonisation, economic and social factors. So far, several scientific publications have been made; according to Meyer, Gracht and Hartmann (2021), the majority of
them have focused on the decarbonisation of road freight transportation regarding sustainability by sidelining the social and economic factors frequently. In a cost-driven road transport industry, the environmental factors do not play an essential role in decision-making, whereas the economic factors are emphasised.

Regarding sustainable road transportation EU is currently emphasising the development of TEN-T core network corridors, where the objective is improved use of infrastructure, reduced environmental impact of transport, enhanced energy efficiency and increased safety (transport.ec.europa.eu, 2021). In their white paper, European Commission mentions a new vision for the future of the road transportation system and the strategy for EU transport development for the next decade. The aim is to draw attention to the sustainable development of road transport infrastructure and reduce carbon emissions without compromising the mobility of people and products (Puodziukas, Svarpliene and Braga, 2016)

2.3 Internet of Things

The RFID community describes IoT as a system of interconnected devices of computers, digital machines, animals, people or objects with unique identifiers that can transmit data over a network without requiring human interaction with the devices. The following characteristics of IoT were defined by Mali and Govinda (2021):

- Ambient Intelligence: IoT devices contain a specific set of instructions and algorithms enabling them to function and react intelligently to particular situations supporting certain specific tasks.
- Dynamic Nature and self-configuring: IoT devices can adapt dynamically to the changing context by gathering data. They have a self-configuring capacity to operate, coordinate and figure out tasks with multiple devices.
- Heterogeneity: IoT devices are heterogeneous, which means they can communicate with other devices and platforms using different hardware proposals and systems.

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2 According to Puodziukas, Svarpliene and Braga (2016) an average truck that burns 1 litre of diesel fuel emits about 22 grams of carbon monoxide, 15 grams of volatile organic compounds, 27 grams of nitrogen oxides and 3 grams of solid particles.
- Unique Identity: Unique IP address or Uniform Resource Identifier (URI) are carried by the devices.
- Enormous Scale: The number of IoT devices connected to one another is of a scale relatively larger than devices connected to the internet.
- Things-related services: Staying isolated IoT devices can provide thing-related resources to the required sources.

2.3.1 IoT for Sustainable Supply Chain Management

IoT has brought forth innovative applications for supply chains worldwide, making the supply chains smoother, faster, transparent and sustainable. With a global network of inter-connected devices, the IoT ecosystem is significantly large; this helps enterprises collect data to improve operational efficiency (Tu, 2018). Internet of Things can strengthen supply chain management, helping the transport industry build resilient, agile and sustainable supply chains for the future. A sustainable supply chain often brings up the term triple bottom line (TBL); TBL includes the models that deal with the performance within the aspects of the environment, social aspects and profitability (Elkington, 1997). The model can be used as a tool to achieve the organisation's sustainable goals by considering the profit, planet and people (Slaper, 2011).

Traditional supply chains negatively impact business processes when faced with disruptions; it leads to high cost, damaged and misplaced goods, increased risk, complexity and many other issues (Al-Talib et al., 2020). Before IoT, data and information transaction was one-directional, causing less transparency; also, as opposed to the smart supply chain, the traditional supply chain lacked collaboration among stakeholders (Al-Talib et al., 2020). Inaccuracy, errors and inefficiency in the supply chain were quite common as there was a lack of real-time data sharing, causing a lack of visibility. IoT establishes a network of physical objects connected to the internet, which allows the stakeholders to continuously monitor and detect goods on the move and take instant measures in case required to reduce waste and cost (Varriale et al., 2021). IoT has been in the spotlight in recent years for supply chains, it has been enabling managers to widely use IoT to locate, identify monitor, and track products and services throughout the supply chain (Varriale et al., 2021). Figure 4 shows the capability of connected devices throughout the supply chain and their ability to build upon one another to perform smart supply chain processes.
These smart and connected supply chains can become increasingly robust and cohesive, and integration can lead to profitable results for all actors involved and increase the overall performance of the supply chain. Supply chain sustainability management is key to maintaining the integrity of a brand (UN Global Compact, 2015), ensuring business continuity and managing operational costs, which can be achieved by reducing wasted time and unnecessary processes, lowering inventory costs, improving an organisation’s reputation and improving sales (Sabir & Irfan, 2014). Table 1 will focus on the components of IoT and the importance of each function in the supply chain, where a detailed overview is presented related to recent research on IoT.

Figure 5: Capabilities of smart and connected objects (Lee et al., 2019)

The transformation of the industry's supply chain to Industry 4.0 is often faced with some challenges because of their traditional reliance on discrete data silos where data is not readily available, management often finds itself at a crossroads in the transformation and adaptability of disruptive technology. IoT can immediately transform the SC into an integrated system if necessary steps are taken and facilitate the SC through the transition to industry 4.0 by bridging gaps via real-time tracking, information exchange and automated handling (de Vass, Shee and Miah, 2021).
In the research paper by Al-Talib et al. (2020, p. 754), the writers present four components of IoT with which organisations will be able to handle disruption and maintain sustainability throughout their whole supply chain-

*Table 1: Four components of IoT importance in the supply chain for transport companies.*

<table>
<thead>
<tr>
<th>Component</th>
<th>Importance</th>
<th>Related work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility</td>
<td>IoT gives the supply chain the ability to track products, deliveries, services and lifecycle of a product. Real-time visibility increases product lifecycle and consumer happiness.</td>
<td>Al-Talib et al. (2020), Robertson (2021)</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Increasing connectivity and integration simplifies the process of gathering and exchanging data among concerned parties. Automated and real-time supply chains have quick reaction times which can save time, money, avoid disaster, loss, damage and theft.</td>
<td>Al-Talib et al. (2020), Bui et al. (2021), (Robertson, 2021)</td>
</tr>
<tr>
<td>Collaboration</td>
<td>The speed of data sharing among required partners and managers in the supply chain can make faster and more efficient collaboration to avoid uncertainties and also gain a competitive advantage. IoT enables flexible instant information sharing but, at the same time, raises awareness of privacy and safety concerns.</td>
<td>Al-Talib et al. (2020), Bui et al. (2021), (Robertson, 2021)</td>
</tr>
<tr>
<td>Control</td>
<td>IoT sensors provide real-time data that exceeds the data collection carried out manually by human resources. Sensors provide fast data and can give predictive analytics through interfaces for better sustainable quality control and decision-making capability over supply chain processes.</td>
<td>Al-Talib et al. (2020), (Robertson, 2021), Chen, Chen and Yang, (2021), Lee et al. (2019)</td>
</tr>
</tbody>
</table>

Thematic analysis by de Vass, Shee and Miah (2021) shows that establishing IoT infrastructure throughout the supply chain increases operational efficiency tenfold. IoT also increases labour productivity; communication speed is improving with new generations of networks, process optimisation, real-time data is being captured for product and cargo visibility, data accuracy is increasing with in-depth data capturing process, improvement, and reliability of security and
surveillance. Chen, Chen and Yang (2021, p. 3929) have presented seven technology research and development directions of IoT that can enable intelligent supply chain -

1. Radio Frequency Identification (RFID) technology
2. Sensing Technology (Sensors)
3. IPv6 can cope with the increasing IP address demands for IoT
4. Instant wireless transmission technology
5. Satellite communications
6. Nano-level, high-intelligence, embedded technology
7. Standardised unified platforms

Socio-technical drawbacks\(^3\) remain a more significant challenge in embedding IoT in the supply chain as the associate stakeholders remain unwilling to share data through collaboration. This reduces the efficiency of using the IoT ecosystem in supply chain operations. Thus, the SC partners must collaborate to utilise the full potential of data collected through these devices.

### 2.3.2 IoT in road transport

Road transportation is the most flexible form of transportation as it can give door-to-door services. It is simultaneously low cost and has a vast potential to be fully autonomous and a pioneer in being a sustainable mode of transportation (Farquharson, Mageto and Makan, 2021). Transportation in the supply chain has the function of moving products from one location to the other. With the domination of the first and last mile over the supply chain, road freight transportation is often criticised for creating congestion in cities, carbon emission, increasing fuel consumption, risk of theft, damage and inability to reach the final destination due to unpredictable conditions like natural disasters, protests, etc (Farquharson, Mageto and Makan, 2021).

IoT provides road transportation with many strategic advantages; it offers better handoff of goods by real-time tracking and faster goods transfers between supply chain partners (Blume Global, 2018). It allows more accurate scheduling making it easier to plan the production and shipping of goods; using IoT and the data collected in real-time, delays and bottlenecks in the

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\(^3\) Barriers are explained in more details in the Section 2.4 of the chapter.
supply chain can be identified, avoided and reloved (Blume Global, 2018). It also reduces the risk of loss, which in the traditional form of road transportation was a significant issue; IoT enhances security, and the goods transported can be tracked to the final customer by ensuring reliability (Blume Global, 2018).

IoT can help transport companies translate data into performance. Couriers can use the data about truck locations and traffic to optimise their delivery routes; data from previous deliveries could be used to predict the possibilities of customers being home to schedule successful deliveries. Logistics companies could reduce costs and carbon emissions by determining the urgency of product delivery and can distribute the delivery system among trucks and trains based on the urgency (McKinsey & Company, 2016).

RFID tags were the first IoT technology adopted worldwide as identification information emitters, a microchip that wirelessly transmitted data allowing users to track and read the data of products, transportation, etc carrying the RFID tag (Xu, He and Li, 2014). It is a non-contact technology that automatically identifies the objects it is installed on and transfers the data through a radio frequency signal (Jiang, 2019). There are four essential layers of a typical IoT network: (1) Sensing layer consisting of physical objects such as actuators, RFID tags, sensors ranging from measuring temperature to life cycle tracker of cargo among many other things, (2) Networking layer supporting the transfer of data through physical objects such as wired or wirelessly, (3) Service layer integrating services and applications through a middleware technology and (4) Interface layer displaying information to the user to interact with the system (Ben-Daya et al. 2019; Farquharson, Mageto and Makan, 2021; Xu, He and Li, 2014). Table 2 shows a brief overview of the technological components of IoT and how it functions, this was presented by the Federal transit administration in their report to congress on IoT in 2017.
<table>
<thead>
<tr>
<th>Technological Components</th>
<th>Description</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensors</td>
<td>Devices that convert nonelectrical information about a physical condition or even to an electrical signal that can be sent to an electronic circuit.</td>
<td>A sensing system observes and creates data without the need for human observation. Sensors can collect information about the position, occupancy, proximity, velocity, pressure, sound, temperature, light, biological elements, and more.</td>
</tr>
<tr>
<td>Gateways</td>
<td>Networking hardware and software components connect one network to another (hubs, servers, routers, etc.).</td>
<td>Gateways allow for signals generated by sensors to be communicated to networks and vice versa; gateways facilitate bidirectional communication between the sensor and the network.</td>
</tr>
<tr>
<td>Networks</td>
<td>An infrastructure of hardware and software protocols that allow devices to share information (Ethernet, Bluetooth, Wi-Fi, cellular technologies such as 3G and 4G).</td>
<td>Networks transmit real-time data collected by sensors to other devices.</td>
</tr>
<tr>
<td>Standards</td>
<td>Requirements and specifications that define how machines identify and communicate with one another.</td>
<td>Data collected by sensors and transmitted over the network are aggregated so they can be analysed; standards facilitate interoperable data handling, processing, and storage.</td>
</tr>
</tbody>
</table>
| Data Analysis Tools      | Data can be processed and analysed for use by transit organisations through the application of statistics, computer programs, and modelling techniques; for example, algorithms can be designed that automatically process and analyse data generated and communicated by specific types of sensors. | Analyses of IoT data:  
  - Aggregate and communicate information about individuals and their preferences,  
  - Can be communicated back through the network to make adjustments in the physical world,  
  - Provide information on patterns that can help us optimise safety, efficiency, and customer experience, |

Smartphones are of regular use in supply chain operations; they bring forth sustainable usage of technology in road transport by eliminating the usage of multiple devices to keep track and trace (de Vass, Shee and Miah, 2021) of drivers or cargos on the move, it leads to the reduction of
waste by minimising the number of devices, and such waste is called e-waste. Global Positioning System (GPS), instant communication (between drivers, customers and warehouse), driver fatigue, fingerprint reading, and verification sign (de Vass, Shee and Miah, 2021), all can be done instantly by using a single device, and in often cases, that can make a regular mobile phone. It saves time and money for SC managers, even though adaptation to unique interfaces might act as a challenge for transport drivers. This is an existing internal barrier that many organisations face even after providing intensive training.

2.4 Barriers of IoT

2.4.1 Limited Resource Barrier
One of the most significant potential risks for natural resources is the increasing implementation of electronic sensors, which leads to an increase in production which in terms consumes more fossil fuel, water and chemicals in the production stage (Nižetić et al., 2020). Naturally, limited resources, such as copper, silver, gold, and palladium, are being used in the process, leading to e-waste, which is ever-increasing with the rapid growth in demand. Barume et al. (2016) state that conflict minerals such as 3TG, which stands for tin, tantalum, tungsten and Gold, are often used in modern devices, showing sustainable challenges in procuring certain resources. Stable elements are usually used in digital technology devices such as IoT devices. Tantalum is a key component of capacitors, lithium and dysprosium are core components of batteries, while indium, cobalt, tin, tungsten and the platinum group of metals are used for electrical components (Blumenthal and Diamond, 2022) in IoT devices. Conflicts Minerals like 3TG come from politically unstable regions, where the minerals are extracted from the earth without following sustainable mining practices (Barume et al., 2016; Blumenthal and Diamond, 2022). Market research firm ‘IoT Analytics’ predicts that more than 21.5 billion IoT devices will exist by 2025 (Greengard, 2021). The predictive consumption number is higher than the 20% electric waste recycling ability and the infrastructure that industries across continents currently possess. According to Nižetić et al. (2020), the annual e-waste is more than $44.10^9$ metric tonnes which is more than 6 kg per inhabitant annually.
2.4.2 Infrastructure, Investment, and Security Barriers

There are external and internal investment challenges regarding implementing IoT infrastructure throughout the supply chain. There is no universal system in place that will allow IoT infrastructure to be implemented quickly. American Journal of Transportation - Ajot (2022) describes the shortage of skilled labour as one of the most significant external factors why many transport businesses fail to implement IoT infrastructure in their company. Ajot (2022) also considers that investments do not exist in IoT because of the high price of setting up the infrastructure. The price seems to be a significant factor when it comes down to adopting IoT. The perceived costs of IoT, according to an industry survey, include process re-engineering, increasing IT staff, cost of RFID tags, cost of IoT system hardware, leasing IoT system, buyout purchase of IoT system and self-development (Rey et al., 2021; Corrêa, Sampaio and Barros, 2020).

Sensors and tags allow effective traceability, but they need to be linkable through the whole IoT ecosystem of the supply chain to ensure proof of delivery and real-time tracing in different modes of transport and cross-country deliveries (Altuntaş Vural et al., 2020). Nevertheless, there is a lack of connectivity among different tags or sensors as they do not communicate with each other. This is due to separate infrastructure investments done by actors according to their needs and further down, this only increases the costs as the sensors do not communicate with supply chain partners but are rather just beneficial for inter-organisational purposes (Altuntaş Vural et al., 2020). According to Altuntaş Vural et al. (2020) a shared cross-industry investment is required for accessing the full potential of IoT infrastructure and its ecosystem of sensors and tags.

Another barrier that many leaders faces and hesitate about is the trust and security threat. Cyberattacks are typical for IoT devices; this makes investment in security another challenging factor. Since intelligent objects hold confidential information, they pose a considerable risk of being exposed to cyberattacks in the road freight industry (Farquharson, Mageto and Makan, 2021). The security of IoT devices is of main concern for end users due to the vulnerabilities the number of devices and third parties involved with the IoT ecosystem might give hackers and
foreign governments the opportunities to penetrate devices and use the infrastructure as a weapon of mass surveillance (Padyab et al., 2019).

2.4.3 Privacy Issues
Drivers of over-the-road freight transport are often uneasy about being tracked, making them resistant to tracking devices that give real-time data of their activities; this might include the speed of driving and how many stops they take to rest. Many modern trucks measure drivers' fatigue and health, making drivers uncomfortable with the technological advance transport mode. Nonetheless, such devices can give early warning to the driver regarding their state and behaviours, such as whether they are distracted or tired, use of cellphones while driving, smoking and random break in potentially risky areas (planetstoryline, 2021).

Another privacy issue will be how a company is utilising the collected data, who is storing them, and whether they are being stored in a manner safe from security threats (Kamble et al., 2019; Whitmore, Agarwal and Da Xu, 2014). Whitmore, Agarwal and Da Xu (2014) argue that IoT devices should carry a privacy policy before collecting data from other devices with whom they are compatible. This might slow down data transfer, and seamless connection among devices will be faced with high latency problems. Padyab et al. (2019) argue that factors related to privacy and trust in IoT include awareness related to the collection of data and use of services. Such as big data services where the concern for personal data protection is quite significant, IoT manufacturers, service providers and the quality of service. Privacy infringement and personal data misuse are the main issues the users fear (Padyab et al., 2019).

2.4.4 Seamless integration and compatibility issue
Successful IoT implementation means having a broader strategic alliance with a wide range of stakeholders throughout the supply chain. Because of the complexity and ability to create value through the supply chain with a wide range of connected products, there will be the involvement of multiple types and layers of partners (Lee et al., 2019). This makes emerging data leakage incidents more likely to be a significant risk. The transport and Logistics industry IoT ecosystem is a vast web of interconnected devices, and one single error might lead to a chain reaction of catastrophic monetary damage and delay in the industry (Lee et al., 2019). The monitoring and
maintenance challenge of all the connected devices is costly, time and resource-consuming. At this stage, data is collected to continuously improve the IoT system and implement the preferred algorithms by the stakeholders or the user of the system (Lee et al., 2019). There is another challenge of compatibility with the existing varieties of industrial software, which becomes a challenge for the devices to be compatible in communicating with one another. Standardisation of IoT devices globally will ensure smart objects and systems integrate smoothly and efficiently among various vendors while at the same time ensuring data safety over the entire network of IoT (Kamble et al., 2019).

2.4.5 Legal / Accountability Barrier

To ensure security standards and regulations, legal information systems must be in place to rapidly develop and adapt IoT in SCM (Kamble et al., 2019). A governance structure for IoT will guide the efficient usage of energy, as well as, governing network capacity and network usage will determine the restrictions on sensitive frequency bands (Bandyopadhyay and Sen, 2011; Kamble et al., 2019; Whitmore, Agarwal and Da Xu, 2014). Establishing a governance structure will allow all stakeholders to dictate the direction of the ecosystem, rather than a single source controlling the whole data flow (Whitmore, Agarwal and Da Xu, 2014). According to Rose et al. (2015), governments and private institutions must continuously collaborate, promote and support technology initiatives and solutions. The IoT ecosystem requires accountability because accountability will improve the efficiency of governance and the whole infrastructure (Weber, 2011; Whitmore, Agarwal and Da Xu, 2014). IoT devices continuously push global boundaries and give rise to cloud computing to handle data seamlessly with instant global access. But due to international political issues, it becomes hard to integrate physical devices and transfer data from countries with tight regulations. It is also a legal challenge for organisations to implement the devices in countries with stricter rules on using or collecting data (Ghaffari, Delgosha and Abdolvand, 2014).

There is a growing public awareness and legal barrier to using IoT devices made by using conflict minerals or minerals from conflict areas where mining practices are not followed (Barume et al., 2016). Various laws and certification standards have been developed to prevent conflicts with minerals' usage in the supply chain -
• The Organisation for Economic Co-operation and Development (OECD) Due Diligence Guidance.
• The Certified Trading Chain (CTC).
• The Conflict-free Smelter Program.
• Dodd-Frank Act section 1502.
• The Regional Certification Mechanism by the International Conference on the Great Lakes Region (ICGLR).

2.4.6 Return on Investment

Traditional investors usually invest with the hope of getting a quick return for their investment. Sometimes that return can come in a year or two, but in the case of IoT, depending on the size of infrastructure implementation, the expected return on investment might take longer than the predicted time period (Luthra et al., 2018; Granjal et al., 2015; Kamble et al., 2019). Padyab et al. (2019) argue that the real challenge is to show individuals the real impact of using IoT infrastructures and technologies and how they can lead to better applications and services, reduced costs, and a more innovative ecosystem. This is because the IoT ecosystem still lacks significant ROI examples (Padyab et al., 2019). Cost is one of the most significant barriers and the primary concern of many stakeholders involved since the payback period is quite long. Investors also have substantial concerns about IoT being so unstructured and chaotic, just like the internet in the 90s (Bujari et al., 2017). Costs are a concern for stakeholders because IoT implementation will increase the overall operational cost of a business through hiring a professional workforce, purchasing and producing intelligent devices, installation, maintenance and training costs for impairing pieces of knowledge to the labours (Sharma et al., 2020). The whole process increases the cost significantly without the foresight of return on investment, which is why many investors see the investment as not worth a while.

2.4.7 Lack of skilled labour

To develop, maintain, install, and manage IoT requires a highly trained professional workforce to work around the clock constantly in an organisation (Kamble et al., 2019). To have the
user-friendly interface of IoT services which ensures IoT functionality, high-end technical and functional skills are required (Kamble et al., 2019). Hopali and Vayvay (2018) argued that the requirement for quality skilled labour is often higher due to various industry involvement in the IoT ecosystem. Companies are willing to hire skilled labour to reduce training costs, which becomes an obstacle to finding the right workforce for specific industries. The fundamental problem in developing countries is inadequate training of all participants in the supply chain to apply advanced technologies and the lack of skilled labour (Končar et al., 2020).

2.4.8 Scalability

Scalability is the key to handling the rapid growth of IoT (Hussain, 2016), but at the same time, with the increasing size of IoT networks and the number of physical devices, scalability is a challenge that many organisations have to face in the future (Kamble et al., 2019). In the supply chain, many devices need to be deployed (Hussain, 2016) to keep up with the connections, which is a primary concern for all organisations involved in IoT standardisation. Further, the networking and communication among these massive number of devices is another concern (Hussain, 2016). There will also be increasing complexities related to data collection, storage, processing, analysis and service provisioning, with which organisations need to keep themselves updated to manage the infrastructure (Kamble et al., 2019).

2.5 Theories

The barriers mentioned are collected from previous research fitting to the current challenges in road transport companies. These are the most common barriers, as they are mentioned repeatedly in the previous selected research. The research paper contributes to understanding the barriers mentioned in the problematisation section of the first chapter of the thesis. These barriers can be fitted to the theoretical framework of the “Unified Theory of Acceptance and Use of Technology” (UTAUT) presented by Venkatesh et al. (2003), where they use eight different widely accepted: 1) Theory of reasoned action, 2) Technology acceptance model (TAM), and its extension, 3) Motivational Model, Theory of Planned Behaviour (TPB), 5) Combined TAM and TPB model, 6) Diffusion of Innovations Theory 7) Model of PC utilisation 8) Social cognitive theory (Carcary et al., 2018). For this thesis, UTAUT can present a framework. IoT represents a
complex and sophisticated technology. UTAUT can be used as it has been used in the past as a theoretical lens for studies associated with individual and organisation IoT adoption (Carcary et al., 2018). Adapting from Carcary et al. (2018), this thesis also aligns with four constructs defined within UTAUT: Performance Expectancy, Effort Expectancy, Social Influence and Facilitating conditions.

1. Performance expectancy is described as the degree of user expectation if using technology will lead to getting benefits. For road transportation companies, performance expectancy refers to the degree to which they perceive that using IoT will improve their productivity and performance (Almetere et al., 2020).

2. Effort expectancy is the degree of ease associated with using IoT devices, and previous research has shown the behaviour of an organisation is influenced by the intention of using complex technology (Almetere et al., 2020; Carcary et al., 2018).

3. Social Influence is the degree to which an individual perceives that important others believe he or she should use the new system (Venkatesh et al., 2003).

4. Facilitating Conditions is the degree to which an individual believes that organisational and technical infrastructure exists to support the use of the system (Venkatesh et al., 2003).

UTAUT is usually used to measure the likelihood of success when introducing new technology (Venkatesh et al., 2003). It allows organisations to understand the drivers behind the acceptance of new technology and how they can emphasise those who are reluctant towards such technology. Carcary et al. (2018) used UTAUT with four constructs in their paper “to identify relevant themes in the stream of research centred on the drivers, benefits, barriers, and challenges to organisational IoT adoption”. Carcary et al. (2018) state the significant benefits, lackings and barriers in IoT adoption for organisations, but there is still a research gap on IoT adoption barriers for road transport companies. Even though UTAUT is often used more towards understanding the acceptance level of new technology (Venkatesh et al., 2003), this thesis will be able to open the door for further research using UTAUT by identifying the barriers involved for road transport companies.
2.6 Summary

The road transportation industry is vital for any country as it contributes to economic growth and stability by moving people, products and animals to the right places at the right time. Road transportation is the most significant contributor to Co2 emission, product waste and time waste, which can be mitigated through investment in the infrastructure of cutting-edge IoT technology. For organisations to be successfully sustainable throughout their supply chain, better control and visibility are required. They have to train the current workforce to be more flexible with technology. This chapter tells us that embracing IoT devices in transportation gives a better understanding of the possible sustainable approach by allowing organisations real-time access to data (Costa et al., 2016). The chapter starts by providing a detailed overview of supply chain and sustainable supply chain management, and it explains how disruption can impact the stability of a resilient supply chain. A subsection in this chapter explains green supply chain management, which differs from sustainable supply chain management. The purpose of introducing green supply chain management in this chapter is to aware readers of it, and readers should consider this if future research is conducted using this thesis in a similar field. It also highlights the necessary function of IoT in road transportation and supply chain. The chapter also provides the importance of IoT to mitigate supply chain disruption and also will provide readers with definition of the green bullwhip effect to show the complexity of the supply chain. Even though the green bullwhip effect is the main topic for this thesis, this section can be used for future research. As green bullwhip effect shows the complexity of the supply chain and the effect it can have on the supply chain downstream and upstream. The chapter also provides a section on previous research on different industries highlighting road transport companies' barriers to implementing IoT in their supply chain.

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4 Suggested reading for the green supply chain management.
3. Methodology

This chapter will present the research method for writing the thesis. Then the primary data collection procedure will demonstrate how data is collected, and interviews are conducted for the thesis. The chapter ends with a brief discussion of source and method criticism.

3.1 Research Method

3.1.1 Research Strategy

From a general methodological point of view, the status of the case study as a type of research is not entirely clear (Verschuren, 2003). Yin (2002) describes the case as a contemporary phenomenon within its real-life context; the distinctive need for a case study arises out of the desire to understand the social phenomena. Hartley (2004) states that case study research consists of a detailed investigation with data collected over a period of time of phenomena within their context. Case study research ranges from a single case study through carefully matched pairs up to multiple cases, various levels of analysis involved from individuals, groups, and organisations to organisation fields and different lengths and levels of involvement in organisational functioning (Hartley, 2004). There is a theory explaining that case studies are applicable in methods where “how” and “why” are expressed in the research question when the investigator has little control over events and when the focus is on a contemporary phenomenon within some real-life context (K.M. Eisenhardt and M.E. Graebner, 2007; Yin, 2002). This study will research the phenomenon of IoT implementation barriers for sustainable supply chain management in the Road transport industry. Gillham (2000) considers the use of multiple sources of evidence as a key characteristic of case study research, which is why the semi-structured interview is taken from multiple industry experts in the fields related to this research. Phenomenon research is used to find the depth of the research question; primary data were collected through interviews, and secondary data were collected from relevant articles and reports published by the case companies. The research follows a qualitative method, and qualitative data is collected by interviewing expert individuals in the related field. Cassell and Symon (1994) argue that
qualitative methods would be very appropriate, focusing on organisational processes, and outcomes, and trying to understand both individual and group experiences of work. Based on the research aim, a qualitative method would be suitable to provide a detailed text overview of the barriers. In contrast, a quantitative method would lack in answering how the barriers take place for road transport companies and why these barriers exist. Qualitative research is less likely to impose restrictions on collecting data based on the complexity involved with the research topic, and a constructive outcome can be provided by following the qualitative research method.

3.1.2 Research Design

Exploratory research is, in certain ways, related to detective work, where the search for clues leads to the phenomenon and the way it unfolds (Stevens et al., 2013). Researchers use various sources to gain insights and information in the search for ideas and clarification. Exploratory research seeks to generate ideas and insights by reading what others have done and discovered about the topic of this thesis, and by saving up valuable time and resources in the search for ideas (ibid). Curiosity is the key when conducting exploratory research as it will help researchers during the data collection process to figure out the need to ask a follow-up question of a respondent who has mentioned some unanticipated answer to a researcher’s query (ibid.). The participants were chosen systematically and rigorously to ensure in a broader sense that they were the expert in their area (Mauksch et al., 2020). With exploratory interviewing, the author is not precisely trying to measure a variable but rather trying to gather penetrating insight into the research phenomenon. The interviews were carried out by Zoom, and face-to-face, where they were asked semi-structured questions as a source of primary data collection. Though some information was also exchanged using email and messaging options. Compared to surveys, interviews provide excellent in-depth knowledge and flexibility. According to Bryman and Bell (2017), interview flexibility appeals to researchers while conducting qualitative research. There were follow-up discussions after each question to prevent misunderstandings in the interview between the interviewer and the respondents. Since the data collection was open-ended, respondents could share further details relevant to the questions asked or in line with the research topic.
3.1.2 Abductive Approach

A research approach is a path of conscious scientific reasoning (Kovács and Spens, 2006). The most common research approaches are deductive and inductive, where both approaches are concerned with the connection between research and theory (Bryman, 2012; Bell et al., 2019). Kovács and Spens (2005) argue that a deductive approach follows a conscious direction from a general law to a specific direction, whereas an inductive approach moves from facts to theory. But there is another research approach known as the abductive approach. According to Suddaby (2006), the abductive approach combines deductive and inductive approaches by moving back and forth between theory and data. In the abductive approach, according to Kovács and Spens (2006), the researcher initiates a creative, iterative process of theory matching or systematic combining in an attempt to find a possible matching framework or to extend the theory used prior to observation. That is why choosing an abductive approach allows the author of this thesis to explore the already existing barriers (Kovács and Spens, 2006) from different industries and frame the research in the field of road transport companies. Abductive research allows the researcher to anchor findings to an initial theory, and then as data collection and analysis progresses, it keeps getting developed and refined along the way (Karatzas, Johnson, & Bastl, 2017).

3.1.3 Locating studies

A combination of keywords has been selected to find related literature and books for information collection, such as ‘Internet of Things’, ‘Industrial Internet of Things’, ‘Sustainability’, ‘Sustainable Supply Chain Management’, ‘Sustainable Supply Chain Processes’, ‘Supply Chain Management’, ‘Supply Chain Processes’, ‘Industry 4.0’, ‘Smart Supply Chain’, ‘Sustainable Development Goals’, ‘Freight’, ‘Transport’, ‘Green Transport’, ‘Road Transport’. For the thesis, Google Scholar (www.scholar.google.com) and Scopus (www.scopus.com) is used as a part of the relevant literature collection. Apple Book (www.apple.com/apple-books/) has been used to access relevant books regarding IoT, Supply Chain Management and Supply Chain processes.

3.1.4 Case Study

A case study is a research study that focuses on a single example of a broader phenomenon to gain insight into a related topic (Gerring, 2013). A multiple case study is where the author
researches the similarities and differences between multiple cases by comparing and analysing data within and across situations (Gustafsson, 2017). According to Bryman (2012) and Bell et al. (2019), researchers must decide whether a single or multiple case study is required to answer the research question. Based on the complex research questions, the author has decided the design for this thesis to be a study of a phenomenon. A case study begins by recognising what ideas or concepts binds the case together (Stake, 2006); for this study identifying the barriers in transport companies and how to overcome them is the idea behind the case study of a phenomenon. According to Stake (2006), an important reason to do case studies is to examine how a phenomenon performs in a different environment. He also argues that for such reason, cases in both typical and atypical settings should be selected. When these cases are selected carefully, the study's design can incorporate a diversity of contexts (Stake, 2006). Since the findings of the phenomenon require at least three confirmations, for the thesis, nine interviews of different companies and experts of different backgrounds are taken to ensure key meanings are not overlooked. Padyab et al. (2019), in their paper, argue that trust in IoT is related to both the information handling practices of IoT manufacturers and as well as those of service providers. Companies like Scania, a manufacturer of transport vehicles with global supply chain operations, have been chosen as the first case, along with Telia and Tele2 as IoT service providers to transport companies. Data from these three companies and six more interviews with different companies and industry experts will give an in-depth understanding of the existing barriers to IoT adaptation in road transport companies.

3.1.5 Case Companies

The criteria for choosing the companies were that they needed to have global or multinational operations background. Scania is a fitting example as a case for this thesis; being one of the largest manufacturers of transport vehicles and also as a solution service provider, the company fits perfectly to the thesis topic of Sustainable supply chain management through the integration of IoT. The data collection from their modern vehicles, through the sensors included in every part of their transport vehicles, gives them the data to make sustainable decisions. Their trucks are also being used as the first and the last mileage across the world in transporting products. Scania’s approach to sustainable transport rests on three pillars5 which give an in-depth and

5 Scania’s three pillars: energy efficiency (optimising the vehicle and driving), renewable fuels and electrification (optimising the energy), and smart and safe transport (optimising the transport system).
holistic view of the usage of IoT in their transportation. Telia and Tele2, among the communication service providers, were chosen for data collection due to their IoT devices and the solutions they provide to logistics firms. Telia Division X and Tele2, which works with IoT providing their B2B customers with IoT devices and solutions, are two fitting case studies for the thesis. They provide sensors and solutions to different businesses to digitise their supply chain management through asset tracking, fleet management, and connected vehicles. DHL as a 3pl company is important due to their global supply chain, and access to their company for data collection can lead to more in-depth research on the phenomenon, even though the contribution of DHL through data collection is minor in this thesis. However, it is easily understandable that the data collected from DHL can lead to a more constructive buildup of the phenomena research for this thesis and future research. RISE, on the other hand, is a research Institute involved with innovative technology such as autonomous vehicles, IoT, etc. Respondents from the companies such as Avia & co. and IIIEE are individuals directly involved either through employment or research with the supply chain and were able to contribute to the research. Further discussion and introduction about them are provided in the empirical results. Electrolux, a multinational home appliance company, is directly connected to the global supply chain and their insights on the thesis were valuable.

3.2 Data collection procedure

3.2.1 Selection of Respondents

The collection of primary data was conducted through semi-structured interviews; the selected respondents hold positions in the company, fulfilling the data collection criteria. The search for the respondents was conducted through LinkedIn; they were screened, added, messaged and requested for an interview. The selection of participants required them to have 5+ years of academic or work experience based on the field they are working in or have studied so that they could provide valuable insight for the research. Due to the complexity of the research, respondents were chosen based on multiple backgrounds ranging from IoT, and supply chain to researchers. Because of the involvement of various stakeholders and partners in road transportation, cross-functional experts from different industries are included in this thesis because they can provide rich, constructive data based on their work experiences. In the case of
Scania, after the first interview, they offered further help by providing information related to the field of research they could find in the form of articles published by the company. There was already a personal connection with Telia as the author knew people working in Telia Division X, a department within Telia specialising in IoT. Regarding Tele2, the interviewee had years of experience in different telecommunication organisations and their previous fields of work were based on IoT. The respondents at each company are directly connected with IoT, Sustainability or Supply chain management to ensure the collected data had no discrepancy. To respect the privacy of the respondents, their name has not been included. However, their position in the company is essential to include in the thesis. The interview process layout has been presented below for a further overview.
Table 3: Shows the anticipated respondents in the interview and the process of data collection

<table>
<thead>
<tr>
<th>Company</th>
<th>Scania</th>
<th>Telia</th>
<th>Tele2</th>
<th>DHL</th>
<th>RISE (Research Institutes of Sweden)</th>
<th>Avia &amp; Co. / CISL</th>
<th>iiiee (Lund University) / plietsch</th>
<th>Electrolux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title of Interviewee</td>
<td>IT Sustainability Lead</td>
<td>IoT Division X</td>
<td>Head of Tele2 IoT</td>
<td>Supply Chain LLP Europe</td>
<td>Senior expert in digital innovation and logistics</td>
<td>ESG board member and academic assessor</td>
<td>PhD Researcher / Co-founder</td>
<td>VP Global Supply Chain</td>
</tr>
<tr>
<td>Date</td>
<td>16th February 2022</td>
<td>February - May 2022</td>
<td>June 2022</td>
<td>April 2022</td>
<td>29th June 2022</td>
<td>3rd July 2022</td>
<td>7th July 2022</td>
<td>15th July 2022</td>
</tr>
<tr>
<td>Data collection (Action)</td>
<td>Zoom (Video)</td>
<td>Zoom (Video) Face to Face</td>
<td>Zoom (Video)</td>
<td>LinkedIn Chat and Email</td>
<td>Zoom (Video)</td>
<td>Zoom (Video)</td>
<td>Zoom (Video)</td>
<td>Zoom (Video)</td>
</tr>
<tr>
<td>Interview time</td>
<td>1 hour</td>
<td>3.5 hours</td>
<td>.30 hours</td>
<td>Null</td>
<td>.30 hours</td>
<td>.30 hours</td>
<td>.30 hours</td>
<td>.30 - .35 hours</td>
</tr>
<tr>
<td>Recorded</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Written Notes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Questions send in advance</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Presentation given by respondents</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Respondent Code</td>
<td>A</td>
<td>B, B2</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F</td>
<td>G</td>
<td>H</td>
</tr>
</tbody>
</table>
3.2.2 Collecting Relevant Information

Data collection was also done by going through the company websites, articles and various report publications. Table 4 gives an overview of the reports and published articles used for the thesis. These also gave a general guide to finding the relevant persons working for the company to be part of the primary data collection process. During the interview, a known directive was given to respondents on the types of data being collected regarding the thesis topic by making it easier for them to align their responses in the direction of the questions asked. The respondents also gave some data as means of internal and web-published reports to read through before, during, or after the interview to get more knowledge about their companies and their contribution aligning to the topic. Table 4 shows the lists of reports and articles used for this thesis. These reports and articles were found relevant and aligned with the research questions. To ensure their validity was double-checked with the respondents, and upon their suggestions were used for the research. EEA, EC, and FTA reports were found through literature review, as they play a significant role for IoT and road transport companies.

*Table 4: List of reports and articles published by organisations used for the thesis.*

<table>
<thead>
<tr>
<th>Published by:</th>
<th>Title</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scania</td>
<td>Code of Conduct</td>
<td>2018</td>
</tr>
<tr>
<td>Scania</td>
<td>The Scania report 2021 Annual and Sustainability Report</td>
<td>2021</td>
</tr>
<tr>
<td>Scania</td>
<td>Scania’s commitment to electrification – our initiatives so far</td>
<td>2021</td>
</tr>
<tr>
<td>Telia</td>
<td>Connected Things</td>
<td>2021</td>
</tr>
<tr>
<td>Telia</td>
<td>Connected Future- White paper</td>
<td>2021</td>
</tr>
<tr>
<td>Tele2</td>
<td>LTE-M &amp; NB-IoT: An Overview</td>
<td>2020</td>
</tr>
<tr>
<td>Tele2</td>
<td>Boost innovation for sustainability</td>
<td>2022</td>
</tr>
<tr>
<td>Deutsche Post DHL Group</td>
<td>On a new level 2021 Annual Report</td>
<td>2021</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Deutsche Post DHL Group</td>
<td>2021 Business Profile: Investors Relations</td>
<td>2021</td>
</tr>
<tr>
<td>European Environment Agency (EEA)</td>
<td>The first and last mile - the key to sustainable urban transport. Transport and environment report 2019</td>
<td>2019</td>
</tr>
<tr>
<td>Federal Transit Administration</td>
<td>Report to Congress on Internet of Things</td>
<td>2017</td>
</tr>
<tr>
<td>European Comission</td>
<td>Trans-European Transport Network (TEN-T)</td>
<td>2021</td>
</tr>
</tbody>
</table>

Interview questions were formulated after carefully selecting scientific articles to collect relevant data contributing to the thesis topic. Reports published by the companies were also used to assist with the writing of interview questions and were also used as a secondary source of data collection. Interview questions were also developed during the data collection process, due to the abductive approach flexibility, new information surfaced, which was utilised to formulate interview questions differently. That is why there is a difference among the interview questions presented in Appendix 2, but the aim relating to the research topic did not change and interview questions are developed surrounding the research question. Due to the complexity of the questions and the data required for the thesis, the respondents suggested collecting secondary data through the company's public resources regarding specific questions in the interview. During the interview process, the questions were also formulated fitting the respondents' reactions to the interviewer's previously asked questions. However, the core of the interview questions stayed relevant to the main research questions. But specific questions to the interviewee were modified based on their background, including sustainability, IoT expertise, research, transport, and working in the field of the supply chain.
3.2.3 Interview Structure

The thesis on Sustainable supply chain management through the integration of IoT is where different topics came together to form research questions. Separately those topics are sustainable Development, road transport, supply chain management, and IoT. To get clear and relevant answers, the respondents were aware of the complexity of the interviews, where the questions will relate to four different topics providing a holistic approach to the research. The complexity of the multilateral presence of topics makes the question asked easily misguided. The questions for the interview were formulated according to the research aim and research questions. The semi-structured interview was conducted, which allowed the interviewer to explore the topic further by asking follow-up questions while still maintaining the same fundamental structure of all interviews (Bryman & Bell, 2015).

Table 3. provides the company name, the title of the interview and date of the interviews, how the data was collected, the time taken for the interviews, whether interviews were recorded or not, written notes, questions sent in advance, and whether the participants provided a presentation or not and finally ending with the coding of the respondent which is utilised later in the analysis and discussion chapter. The table shows that certain interviews were not recorded, and that was due to either technical error or the denial of recording request by the interviewee. Only two companies were prepared with presentations and for that, the row ‘Presentation given by respondents’ is shown in the table. The interview structure had no criteria of requesting respondents to present the company or be prepared for the interview with a presentation. Notes contributed as a form of data collection for non-recorded interviews.

3.2.4 Analysing Data and Coding

According to Bell et al. (2019), analysing data is a means of finding a path through the data collected to answer the introduced research questions and fulfil the purpose of the study. The most commonly used method for analysing qualitative data is the usage of coding; it is a process of reviewing transcripts and attaching labels to parts which seem to be of potential relevance to the paper (Bell et al., 2019). This method is best suited to analyse data for this research, where semi-structured interviews are conducted to collect relevant data. The recorded interviews were transcribed by going through the recorded videos twice to ensure the transcription is done
correctly. The interviews with just notes and no recording were already in the form of transcription. After ending the non-recorded interviews, recalling the conversation and noting down the conversation were done instantly to ensure no data was lost. After performing all the interviews, the data collection went through conventional content analysis in terms of continuous comparison with research articles and coding the outcome. The data collected was categorised based on the barriers companies encounter; the questions asked also provided the author with knowledge on IoT’s benefits for road transport. Collected data were analysed and coded to compare internal and external barriers to adopting IoT in road transport for a sustainable supply chain. The coding scheme was formed by following a conventional content analysis where repetitive barriers were highlighted from articles read and the exact words appearing in different industries. After noting the initial analysis, the process continues through the first two interviews; labels initially found for codes emerge to fit with the transport industry barriers. Codes then are sorted into categories based on how different codes are related and linked; it is divided among internal or external barriers (Hsieh and Shannon, 2005).

Table 5: Coding Scheme of Barriers

<table>
<thead>
<tr>
<th></th>
<th>Internal</th>
<th>External</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource Barrier</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Infrastructure, Investment and Security Barriers</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Privacy Issues</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Seamless Integration and compatibility issue</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Legal / Accountability Barrier</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Return on Investment</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Lack of skilled labour</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Scalability</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
3.3 Source Criticism

Data collected for the thesis through interviews has a possibility of being biased in the sense that each respondent answers the relevant questions based on their perception and knowledge related to the best interests of their organisation. Due to requests, interview questions were provided in advance to certain respondents, which might lead to skewed results. Nevertheless, the respondents are knowledgeable agents in their field of work, where they have gained years of experience to shed additional information relating to the topic. To gain a better understanding, the respondents were constructive in describing facts and were relatively speaking in a strategic or political term where actions needed to be taken, and this gave a richer insight into how the organisational culture works in the respondents' company.

Scientific articles chosen as a source of data were peer-reviewed; this gives them reliability as a source of information. Sustainability reports and reports on IoT, connectivity and transport published by the case study companies were also used as a secondary data source. These secondary sources are primarily from three focused companies for this thesis: Scania, Telia and Tele2. However, published reports from DHL, FTA, EEA and EC were also used for the thesis. Also, reliable websites and books were also used as a source of secondary data. According to Gioia, Corley, and Hamilton (2012), as authors, we often make these ground assumptions that we are pretty knowledgeable and that we can create patterns from data and formulate questions in theoretically relevant terms. It might make the author biased toward interpreting the data collected from the interview and the secondary sources.

3.4 Methods Criticism

According to Bryman & Bell (2017), qualitative research has often been criticised by researchers who prefer a quantitative approach because the quantitative design provides a more reliable result than a qualitative design, which is often argued as a storytelling type of research. Often many researchers prefer the combination of both qualitative and quantitative approaches, which might result in superior, reliable, and interpretable research. Even though a mixed approach is more reliable as it can tell a constructive and informative story through data analysis, qualitative research has the benefit of being not-bounded by limitations, unlike other approaches.
3.4.1 Research Quality

The research quality evaluation of the data for papers is usually done based on the criteria as follows- Credibility, Reliability and Validity. Since research quality is heavily discussed among researchers and practitioners of quantitative research (Bell et al., 2019), qualitative research can also adopt the terms to evaluate the quality of the research. This research paper's credibility, reliability, and validity will provide the quality.

3.4.2 Credibility

For this research, the author explored the concepts of sustainable development, sustainable supply chain management, and IoT integration in road transportation across multiple companies. After exploring relevant publications of scientific articles from different sources, the author developed the conceptual framework, which helped to produce diverse organisational knowledge and their approach to sustainable supply chain management through the integration of the internet of things.

3.4.3 Reliability

Reliability usually refers to whether the results produced through data collection are reliable in terms of repetition where the research would get the same outcome. Saunders et al. (2009) argue that data reliability means that consistent results are achieved through similar techniques, and other observations would be similarly made. There should also be transparency on how sense was made from raw data, according to Saunders et al. (2009). In qualitative research, reliability is questionable because some diverse definitions and paradigms should be taken into account based on the relevant data collected by the author. Since data collected came from various sources with different backgrounds and countries. This could give rise to discrepancies in data and the information found through interviews. Consistent between previous research and empirical data is a way to keep the study reliable. It is well-known that the author's interpretation is usually drawn from this kind of research. For that reason, some critique around this research is involved as the research itself will not be a fit for the whole transport industry. It is, therefore, crucial to be thorough in the scope of this research to find significant patterns and conclusions.
3.4.4 Validity

Validity refers to the conclusion the author draws from the research paper, whether the author measures, observes and identifies what is needed to be estimated. The validity of this research paper can be divided between internal and external validity. Internal Validity is usually related to the issue of causality in the study (Bryman, 2012); data for this research paper was collected through semi-structured interviews; in that scenario, causality cannot be demonstrated. Instead, according to Bell et al. (2019), evaluating the credibility of the thesis is possible, which equals to internal validity criteria. Andrade (2018) highlighted that qualitative research still has a problem because the findings and conclusions are usually based on the researcher's judgement.

To emphasise internal validity, Bell et al. (2019) suggested two techniques such as triangulation and respondent validation. In 3.4.3 Reliability, the author mentioned that the data is gathered from multiple sources, which is considered triangulation. Also, respondent validation was used, which refers to seeking confirmation of the empirical findings from the interviewees after interpreting the collected data. This thesis has considerable internal validity since the interviewees have agreed on the existing barriers and provided information according to the interview questions.

The second concept is external validity which examines if the results of this study can draw a somewhat generalised conclusion (Bryman, 2012; Andrade, 2018). Phenomena study findings usually provide theoretical generalisation; unlike quantitative research, it is difficult to reach a fully generalised conclusion. The benefits of phenomena studies are that to be able to specify context-specific settings like culture or social factors, which cannot be explained in quantitative research. By including different types of actors in this thesis: transport, communication service provider, third party logistics (3pl) and researchers, the author aimed to generalise as much as possible, making it similar to companies operating with IoT to achieve sustainability in their supply chain. To be sure, it must be taken into consideration that the results of this thesis will differ if put into different contexts. It means the result of this thesis will not be the same for all actors who have different roles in the transportation industry; this may include public road transport or the gig economy. This means the research lacks external validity.
3.4.5 Ethical Considerations

Bell et al. (2019) discuss ethical concerns which are related to this thesis, and such are informed consent and data management. In terms of informed consent, all participants of the interviews were made aware of the thesis, and they willingly joined the interview session, fully knowing about what they would be discussing. They were free to choose whether to participate or not, and consent to the recording and taking notes of the Interview was asked before the process started. Regarding data management, the author keeps all the recordings and notes without giving access to anyone. Since no participants asked for the recording and notes, neither was given to anyone. If requested, the author would have given the recordings and notes being asked by the respective individual to whom the collected data belonged.
4. Empirical Results

This chapter presents the empirical findings from the companies interviewed for the thesis. This chapter has three sections; the first introduces the companies. The second section discusses the internal and external barriers and the importance of IoT discussed by the interviewees. The chapter ending summarises the empirical findings.

4.1 Presentation of the Companies and their respondents

Scania

Scania is a world-leading commercial vehicle manufacturer; its origin started in 1891 as a manufacturer, but with time, Scania also started providing general industrial applications. Scania, at its core, is pushing for net zero by 2040, ten years earlier than the 2050 net zero goal set in the Paris agreement; the aim like Scania’s is driving the transportation industry drastically toward sustainability. They currently have more than 500,000 trucks connected, giving access to real-time data used to analyse vehicle performance for lower fuel consumption and fewer carbon emissions. Scania has a tremendous investment in connectivity and data sharing, giving them valuable insight into how customers use their services and products. Connectivity is done by telematics devices, vehicle sensors, mobile devices, and devices with multiple functionalities. These provide fleet managers with a vast amount of information about how efficiently the truck operates and can show them when it operates outside standard parameters. Companies using Scania’s products have the functionality of tracking, tracing, controlling, visibility and monitoring vehicle health, among many other things.

For Scania, several aspirations make up sustainable transportation. Transportation should be inclusive, safe, clean, healthy and decarbonised (Scania Group, 2019). These aspects provide transport solutions to be sustainable, from which many of these aspects are being handled head-on by Scania and their partners through collaboration (Scania Group, 2019). Table 6 describes those aspects briefly.
**Table 6: A Vision for Sustainable Transport (Scania Group, 2019)**

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclusive</td>
<td>Transport should be accessible to all, including users for whom access to current transport systems may be restricted for any reason. Transport solutions could also be designed for equality of access when it comes to gender.</td>
</tr>
<tr>
<td>Safe</td>
<td>Transport should be safe for drivers and transport users and all other road users, including pedestrians, cyclists and other road vehicles. The concept of safety should extend beyond physical safety: for example, it should be safe for women to use public transport without fear of harassment. If a transport solution is unsafe for certain groups to use or perceived to be so, it is not accessible to all.</td>
</tr>
<tr>
<td>Clean</td>
<td>Transport should minimise polluting emissions. Sustainable transport can also contribute to a cleaner environment by providing uses for products and materials that would otherwise go to waste – for example, by using agricultural waste to create biofuels. Products should be designed and manufactured in a way that minimises waste at every stage of the product lifecycle.</td>
</tr>
<tr>
<td>Healthy</td>
<td>Transport solutions should minimise harm to health. Less polluting vehicles contribute to a cleaner environment that is less harmful to human health, particularly in urban areas. Sustainable fuels such as biofuels can also contribute to human health by improving soil quality and access to clean water. Sustainable transport can also contribute to mental health by alleviating stress and other conditions associated with traffic noise, congestion and overcrowding.</td>
</tr>
</tbody>
</table>
| Decarbonised     | Finally, for the transport system to be sustainable, it must be decarbonised. This involves breaking the system’s dependency on fossil fuels by switching to other energy sources such as electrification and renewable fuels. It also
involves engineering for better energy efficiency and providing real-time data to make transport flows more efficient. Decarbonising transport at the speed and scale required by the Paris Agreement demands rapid and widespread transport and energy infrastructure changes – a shift that calls for bold, coordinated action across the entire transport ecosystem.

Telia
In 1853, the Swedish state founded the Royal electric telegraphic administration, which came to be known today as Telia. A hundred years after its foundation, the business was transformed into Televerket, which faced competition from foreign telecommunication companies over time. After facing immense pressure with outdated technology and strategy, Televerket was restructured and was named Telia AB in 1993. After that, they were being able to compete with private companies and still thrive as one of the most optimal choices of communication service providers in the Nordic region. Telia can now provide IoT solutions among traditional telecommunication services (Telia Company, 2022). One of their fastest-growing departments is Telia’s Division X, which provides IoT services to businesses and customers.

Regarding sustainability, the communication service-providing industry is not usually at the top; nonetheless, Telia is a perfect example of its climate-neutral value creation throughout the business approach. By 2020 the organisation has become climate-neutral, and by 2030, it is aiming for a net-zero carbon emission throughout its entire supply chain. Telia, with its services, aims to better people's lives and create social development, helping families and businesses to stay connected over distance through uninterrupted 5g services and giving rise to digital nomads and digital entrepreneurs (Telia Company, 2022).

Tele2
Tele2 is a Swedish telecommunication company founded and funded in the 1990s by Investment AB Kinnevik. At first, they were called Swipnet and were later renamed Tele2 in 1993. Tele2 now operates globally, providing solutions like sustainable sim cards, roaming, asset management and many other IoT-related solutions. Tele2 in 1997 merged with Comviq and
Kabelvision, yet retaining the name Tele2. Tele2 in Sweden operates with 100% Carbon neutral with triple-A rating MSCI ESG Ratings and Top Prime Rating from ISS ESG Ratings.

Tele2 continuously revises and updates its impact on the environment and controls the supply chain's impact. According to Tele2 (2022), companies involved in using their IoT devices and services keep increasing their business and sustainability value. They emphasise an energy-efficient 5G network, a long life span on devices and sim cards, and also follow up UN SDG in its core. Tele2 is in the role of becoming the sustainable industry leader among communication service providers.

**DHL**

DHL is a 3PL German logistics company which provides courier, package delivery and express mail services. It is one of the world's largest 3pl companies, and it has held itself as a prominent market leader ever since it was formed in 1998 through a merger between the German Deutsche Post and US company DHL. The German side player was initially called Deutsche Bundespost in 1950, and in 1995 it became Deutsche Post AG, one of the three companies that merged from the previous state company.

DHL has more than 571,974 employees worldwide, with countries it reaches and serves over the count of 220. It has 2,200 flights regularly worldwide and 100,100 service points with 37,700 vehicles in its express transportation fleet and more than 280 dedicated aircraft (DPDHL, 2021). Its most profitable core among the transportation fleet is air freight, followed by road and ocean freight.

**RISE**

RISE Research Institute of Sweden is a state-owned research institute and innovation partner collaborating with academies, universities and industries of both private and public sectors. Rise institute ensures the competitiveness of the Swedish business community on an international

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level and contributes to a sustainable society (RISE, 2021). The participant is a researcher in RISE an innovation and logistics specialist with knowledge of digitalisation and IoT ecosystems. This is due to the participant's previous work and 20 years of work experience with logistics and transport manufacturing companies.

**CISL**
Cambridge Institute of Sustainable leadership (CISL) is a globally influential body of Cambridge university providing education for developing leadership and sustainable economic growth. The participant has a background ranging from being a partner of sustainability and ESG of Avia & Co. for six years and a tutor for CISL online courses for more than two years.

**IIIEE (Lund University) / plietsch**
The participant is a PhD Researcher in Sustainable Business Models & Organizational Transformation at the International Institute for Industrial Environmental Economics (IIIEE) at Lund University. The participant is also a co-founder of a sustainable packaging company operating locally in the city of Lüneburg, Germany, for the last five years. The participant's educational background for the previous ten years ranges from sustainable environmental studies, sustainable development, business psychology, environmental management and policy and an MSc thesis project on technologies for monitoring supply chain sustainability risks.

**Electrolux**
Electrolux is a Swedish multinational company selling and manufacturing home appliances and has been established since 1919. Electrolux also works with connected appliances through IoT for consumer and commercial appliances to make the smart home and connected kitchen. Electrolux is considered to be the second largest appliance maker by units sold. The participant is the vice president of the global supply chain in Electrolux, with more than fifteen years of experience in supply chain management.

**4.2 Primary Data and Interviews**
This section of the chapter will provide the data collected through interviews based on each organisation involved by dividing them into separate subsections, which will include internal barriers, external barriers, and benefits encountered or observed by the respondent regarding the
IoT implementation on road transport companies. Even though similarities exist through the results, rather than discussing the similarities and differences in this section, a comprehensive analysis is shown in the analysis and discussion chapter. Since individual respondent of the companies has different work, cultural and academic background, it seemed fit to keep the data isolated in this section better to understand the respondent's perspective on the research field. The separate sections also provide data based on the different companies and respondents from different countries; these isolated results could be used for future research purposes on a particular company or case.

4.2.1 Scania

Internal Barriers-
Departments within the company need to be more knowledgeable about one another because those working with sustainability do not have a broader knowledge of IT and vice versa. Due to minimal understanding, investments are forwarded in making the engine more efficient rather than investing in software. Software investment will allow Scania to analyse the abundant data collected from the engines to tweak their performance or even lead to engine innovation. Low awareness within an organisation is a problem and can be mitigated if departments have a broader knowledge of one another. The problem is far-fetched enough to exclude IT departments from the whole ecosystem and life cycle assessment in Scania. According to the interviewee, even though the company has come further than most regarding sustainability, there is no structured collaboration among departments and stakeholders to involve each other in their operations to utilise and understand each other's data collected from the trucks and the devices.

Scania has something called a data league where all the data collected from half a million vehicles is being stored. A lot is being used to understand emission, engine performance, and routing, and the logistics team is using a lot too. But in comparison, the most valuable data is being sat idle as they are still trying to figure out its usage and importance for the company. Efficiently utilising these data is crucial, and Scania is still trying to improve. Electrifying the vehicles and making an autonomous fleet will be efficient, sustainable and, at the same time, very challenging; this will require radical change management. Internal challenges like drivers and stakeholders will go against these issues. However, strong leadership will bring about
changes, and for that, the respondent said, “So in terms of leadership, I would say, sustainable leadership in the IT industry is needed, awareness is like a key component, and this is low at the moment.”

External Barriers-
Scania is in the hardware industry, which still operates by depending heavily on fossil fuels with a very high carbon emission rate. The carbon emission problem is increasing faster, which dwarfs the progress they are making in the green truck or any other technology that can reduce carbon emission drastically. The emissions are happening more quickly than anticipated due to society's dependence on fast purchasing. To meet society's demand, deliveries are made at a rate without calculating the environmental impact. The environmental demand for lowering carbon emissions is higher than ever due to the rising awareness about global warming and the demands of stakeholders to make green policies with the Paris Agreement in focus. Using science-based targets, tracing and sourcing raw materials, including the production of vehicles, the overall process produces around 7% emission. The remaining 93%, of emissions, occur when consumers use Scania’s vehicles. Downstream the barriers of collecting data to make product improvements by reducing carbon emission is a big challenge because once consumers buy the vehicles, they operate in the best fit. There is a mixed demand today from stakeholders involved as some wants to meet sustainable goals, and at the same time, many want faster, cheaper and more efficient transportation to meet their supply chain needs. Demand is so different as many transportation companies are still willing to buy just a normal truck without integrated devices. It is significantly challenging to force customers to buy interconnected and sustainable trucks without losing them.

Benefits-
Environmental footprint created by vehicles can be reduced by 15% if the data collected from the vehicles are appropriately utilised. In the heavy vehicle industry, Scania is challenging to be the most sustainable company by introducing green trucks and making the existing trucks as environmentally friendly as possible through a connected system. IoT and data collected from the devices are vital for Scania to apply eco-design in their vehicles. This leads to environmentally efficient vehicles with quality and safety. Depending on the market, these data
can provide additional controls to their vehicles and provide the opportunity for Scania to sell digital services.

“But we also have to be open-minded to that, maybe we will even sell services in the future which weren't connected to a vehicle, maybe we will sell the data from the connected vehicles running around to people planning cities, urban planning. Because the trucks really, since they are sending so much data all the time, the data is very valuable to people who do urban planning, with doing the infrastructure and understanding where are charging points and all these different things we could sell. Like the data or digital services even.”

Due to different regulations in different countries, such controls involve air and noise emissions, usage of fuel. It is worth noting that the pressure Scania faces from institutions, governments, customers, and other organisations, forces them to comply with current laws within the EU and even outside of the EU in different countries of operations because the industry itself is not globally environmentally friendly. Scania exerts normative pressure on its suppliers to adopt environmental management because Scania also gets pressure from specific customers to be more sustainable in their supply chain. Though pressure from Scania’s customers does not make them typically adopt the sustainable practice in their supply chain, the matured awareness of environmental degradation associated with the industry pushes Scania towards a more cooperative sustainable supply chain. In the context of Scania being in an environmentally aware sector, normative environmental pressures tend to be more effective in adapting SSC than coercive ones.

Potential opportunities can only occur through collaboration, and collaboration within the supply chain is necessary to improve supply chain resilience and efficiency. Transportation and supply chain innovation can only happen when data and knowledge are shared among partners; this will increase transparency and efficiency. That is why Scania is working with Telenor and Ericsson to use their devices and solutions for sustainable fleet management. By building relationships with all stakeholders, whether internal or external, with shared knowledge, Scania can build a robust supply chain and increase industry resilience. Data sharing increases collaboration among supply chain competitors to be resilient toward a supply chain disruption. Data sharing can help to
mitigate any environmental damage during disruption and also prevent or aware others from trying to take competitive advantage of the situation.

4.2.2 Telia

**Internal Barriers -**
Micromanagement is a problem that employees in transport companies have to deal with, especially those working with delivery. The business model creates the pathway for managers to adopt practices of micro-managing employees by gathering data on their driving patterns.

“There is real-life evidence on how logistics companies are using data to optimise their delivery system thinking of efficient, cheap and successful delivery of products without considering the human factor, and this has been happening in many countries.”

Managers tend to be harsh on employees if they decide to do something not on the optimised routing plan, for example, stopping at a petrol station a few miles before the one in the program. A minor disturbance in the logistics flow might change the management’s opinion of a driver. Trust is an essential internal barrier; it is because of high-security threats, and companies without the capital to invest in a department dealing with cyber threats usually end up operating traditionally. A distorted mindset of the organisation and its member is a barrier; if the corporate culture does not allow innovation, the company will not be flexible in using IoT devices.

**External Barriers -**
The power dynamics of a supply chain are challenging for managers to approach supply chain with a sustainability viewpoint. Due to different stakeholders being involved both externally and internally, it is hard to convince everyone to start using interconnected devices unless demand drives them. Investment in IoT is a factor that many misunderstand; ROI is not fast, so stakeholders are not keen to support a progressive approach toward IoT. Cross-country data regulations and governments' policies might force the company to use the data in a specific manner which do not violate the policies of different countries. Even though Europe has similar data protection regulations, transporting products by road across the continent is a bit challenging. Certain transport companies still operate with a traditional business method because
there is no pressure or demand in the supply chain to use this technology. The technicality and availability of skilled labour in specific geographical locations make it harder to utilise the total capacity of IoT.

Systemic risk exists in the supply chain; disruptions can happen when an unexpected event shocks the whole supply chain, and companies can not absorb the shock. IoT can help collect data during the interruption to mitigate damages and give prescriptive analytics. However, it is of utmost importance for supply chain managers to have a system that can reduce vulnerabilities and make the supply chain and transport network more resilient. Implementing a new business method or adapting practices set by external stakeholders might be beneficial to face disruptive challenges. However, if it is not focused on innovation, companies could overlook the necessity of IoT in transport networks.

**Benefits**

Devices can be used by any company willing to invest in them, but the reality is how they are utilising the data. If a company is good at collecting a vast number of data without knowing its potential, then those companies are as good as the traditional companies, or maybe just a bit better. Unlocking the full potential of data will increase delivery efficiency, customer satisfaction and the ability to drive demand in different channels. Transport companies can use breathalysers to ensure driver safety and reduce accidents; the technology reads the alcohol level and other anomalies. These measurements do not hold any privacy problems as the name of the drivers are not saved or used. Instead, the data shows the driver as an entry with a code number, keeping their actual name private.

Connected vehicles through devices will enable supply chain managers to react quickly and efficiently manage their fleet during a crisis. Miips devices, routers and asset tracking are just a few examples of IoT devices Telia provides to logistics companies or customers, depending on the industry. It is hard to get information on how sustainably raw materials are being processed and sold in the market by suppliers; this is mainly an issue for companies focused on sustainability at its core, like Telia. But end-to-end tracking through interconnected devices will give every company an overview of things happening in every step of the supply chain, and
using those data; actions can be taken to implement a sustainable approach for every stakeholder involved.

Telia provides roaming services to transport companies that is beneficial for data transfer when the deliveries take place by road through borders. Telia has broader network coverage with continuous customer support and deals with multiple telecommunication providers. With this benefit, the central hub of a company’s logistics process will never lose track of products and can benefit from smooth fleet management with connected vehicles. According to the respondent, if appropriately regulated and adequately monitored, IoT devices can save our planet. It is impossible to keep the cost down with increasing scalability and the production of sensors. With these sensors, problems like waste management can be met swiftly, and disease outbreaks can be prevented.

**The second respondent**

**Benefits**-

With Telia devices and solutions, customers in various industries can benefit from many IoT functionality. Such benefits include asset tracking, smooth logistics flow with route planning and operational efficiency. Problems like congestion in warehouses or empty trucks can be optimised with IoT devices. Lpwa networks used by devices are sustainable as they have a longer life span, less energy consumption, and long-lasting batteries. Security of both cargo and data is ensured through enterprise-grade IoT. The geo-fencing alarm is available for off-road cargo, providing transport companies visibility and control. Real-time map generation and analytics are shown with a customisable dashboard for truck drivers' flexibility. They can also connect to their system for smooth data transfer without any connectivity issues. Measuring speed, temperature and humidity is one of Telia's many advantages of IoT devices.

“IoT is cutting edge we offer connectivity without compromising quality and service, data transfer takes place faster and safer over the boundaries and provides an accurate reading of applications with real-time feedback which can be observed through user-friendly interfaces.”
Sim cards embedded in devices include network connections with international service providers for global IoT connectivity without any middleman involved. This gives the parent company complete control of its data without the risk of being skewed or hampered in certain ways. The sim cards are also sustainable because they last very long and do not need to be changed if drivers have to travel across borders for deliveries, as international roaming is included. The sim cards are also temperature resistant against the harsh weather of the north and south. The network connection is industry standard for being future-proof; they are secured in data transfer and have a firewall and routing system to prevent a cyber attack. Telia provides their clients with DDoS protection, intrusion prevention system and traffic anomaly detention; there is total control over IoT transport security with self-service VPN management.

4.2.3 Tele2

Internal Barriers-
One of the most significant Internal barriers is the business model followed by traditional transport companies; they might be reluctant to sharing data with suppliers of different tiers due to their company policy. Managers might be reluctant to technological changes, which makes it harder for companies to change towards a data-driven company. Lack of internal skilled labour can lead to the company not realising the need for IoT implementation even if there is external pressure from other stakeholders in the supply chain.

External Barriers-
Companies willing to use technology for their benefit, whether they see it as a competitive edge over others in the market or as a way to achieve financial gains through optimising the supply chain. When new companies use IoT devices, they usually purchase them from solution providers until or unless the company is big enough with its in-house R&D to support the technological development. However, transport companies usually subscribe to communication service provider's solutions. For the companies, it is a barrier since they do not have in-house skilled labour to tailor the devices or the interface according to their need; these companies are usually stuck with what the solution provider provides. They have to work with industrial functions with a pre-installed user interface as an instant all-in-one package. Usually, not getting
a return on investment fast enough, the transport companies decide not to purchase any other devices in the future, leading to the complete abandonment of IoT integration in the supply chain.

The global supply chain and transport network are usually considered the nation's backbone in this century. External shock can happen anytime, which is why government involvement is ongoing in many countries through a collaboration with private organisations to mitigate the external threat. This means that political, economic and security factors in regulating the complex supply chain have led to cooperation between governments and companies across the border and locally. IoT can help with risk management at a certain level, but then again, many big organisations' refusal remains, making it harder since they have security concerns over data sharing.

**Benefits-**
When supply chain managers make data-driven decisions for the procurement of raw materials or delivery of final products, they usually consult their suppliers on the availability of raw materials. To check the stock level available, the suppliers typically have a system that can be connected with devices and tags to trace their location in the warehouse to see the level stored. Suppliers might allow the downstream managers to access inventory information for production and delivery planning through interconnected IoT devices. Traditional supply chain managers lose much time using pivot tables to track and trace the goods in the supply chain, whereas IoT devices can give visibility and control over the products throughout the entire supply chain. This gives managers the benefit of making faster decisions based on the market reaction or consumer demand. Competitive advantages can be gained by using IoT; companies can optimise their resource-based view. A company’s strategy is based on professional diagnosis, creative solutions and efficient implementation. This can be further developed through real-time updates, demand forecasting, compliance, auditing and collaboration protocols.

IoT is still at its beginning; even though the technology has been out there and being used for so long, it is taking time for people to understand the benefits it carries in a day-to-day lifestyle. The scalability of IoT will grow exponentially, and the benefits it will provide in the future are still a
significant research area. It will detect disasters, prevent goods from getting damaged and theft, and make smart logistics even smarter. Possible development preventing disease outbreaks is going to be the new frontier of IoT; logistics firms will be prepared to deliver more efficiently and effectively to areas where medicines are needed. Supply chain compliance can be achieved through the internet of things technology with the ability to manage exposure associated with third-party operations and optimise their value.

IoT devices are consuming power which, in return, is not sustainable, but Tele2 is pushing to make energy-saving devices with a longer lifespan. Table 7 below gives a glimpse of the current devices provided by Tele2 and its wide range of applications. A sustainable business approach being the core of Tele2, they are constantly thriving to provide solutions and devices that have a longer end-of-life cycle with sustainable end life through reusable parts.
Table 7: LT-M and NB-IoT, low power consuming IoT devices with a longer life span (Lembke, 2020).

<table>
<thead>
<tr>
<th>Application</th>
<th>Description</th>
<th>Key Requirements</th>
<th>LTE-M</th>
<th>NB-IoT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring</td>
<td>Periodic gathering of information from stationary assets</td>
<td>• Low power usage</td>
<td>Suitable (however slightly higher device cost compared to NB-IoT)</td>
<td>Suitable (lowest possible device cost)</td>
</tr>
<tr>
<td>Tracking</td>
<td>Continuous tracking of an asset's position to determine its location at any given time</td>
<td>• Low Power usage • Mobility • Low latency</td>
<td>Suitable</td>
<td>Not Suitable (no support for mobility, high latency)</td>
</tr>
<tr>
<td>Predictive Maintenance</td>
<td>Gathering information from an asset and based on that information, perform predictive maintenance or trigger other actions</td>
<td>• Low Power usage • Low latency</td>
<td>Suitable</td>
<td>May be Suitable (if latency requirements are low)</td>
</tr>
<tr>
<td>Remote Steering</td>
<td>Able to control a device in near real time and be able to perform actions straight away, such as adjust or turn on or off</td>
<td>• Low Power usage • Very low latency</td>
<td>Suitable</td>
<td>Not Suitable (high latency does not allow near real time actions)</td>
</tr>
</tbody>
</table>

4.2.4 DHL

**Internal Barriers**-
Corporate culture and the acceptance of devices used throughout the whole supply chain and among the internal workforce is an important reason why many companies usually do not promote the usage of tracking devices. Tracking and tracing give a false idea to individuals whose beliefs are traditional. Also, people with a different political stand might find it challenging for the government to access their private data.

**External Barriers**-
Governance is initially challenging; many managers struggle to make policies and rules based on their business and stakeholders connected to the IoT ecosystem. No one knows who is in actual control over the data flow among various supply chain partners. Collaboration exists without
authority, but if data get leaked due to cyberattacks, holding an individual company responsible is impossible due to the broad network of interconnected devices among many participants in the supply chain.

**Benefits-**

IoT has the advantage of providing a cold-chain process. This technology helped DHL track and trace medicines to keep the measurement of temperatures perfect throughout the whole supply network. It adds the benefit of increasing the shelf life of perishable goods transported over a longer distance during summer. Fuel efficiency and CO2 measurement are optimised by measuring through embedded sensors within fuel tanks and other parts of a vehicle.

Data collected from internet of things devices will allow us to dig deep into the best practices of global fleet management. Optimising routing in real-time using IoT saves up a lot of time and fuel consumption leading to less CO2 emission. Storage of products can be optimised as IoT devices are also often installed in the product packaging.

**4.2.5 RISE**

**Internal Barriers-**

The cost of the infrastructure of the IoT ecosystem is often a colossal challenge for many companies. When companies use IoT devices to trace products, the prices tend to increase if the size of the tracked shipment keeps expanding. Individual tracker is often used in one pallet in the cargo, depending on the type of products transported. Often, the products having these trackers are precious cargoes such as chemicals, machines, expensive perishable items, military equipment, aid to countries abroad and many other things. These precious cargoes require high maintenance, concrete traceability and visibility through an expensive IoT setup. Even though privacy issues vary from company to company based on their data handling policies, IoT is seen as a problem because customers’ and employees' data are being made available to suppliers connected through a shared information system with the company. With connected vehicles, for example, Scania, managers can see the movement of the fleet and can trace individual trucks, such as who is driving the truck, where they are stopping, and for how long. These kinds of tracking and tracing can turn into a micromanagement problem within the company.
Small transport companies usually operate in a traditional sense of family business, where generations have been running the business with the same vision as their predecessor. This investment and interest in IoT or any new technology like connected vehicles are far-fetched because they do not have any business innovation model. Traditional transport companies are not focused on a sustainable approach unless forced upon by the stakeholders. Scania faced infrastructure problems as they wanted to implement a sustainable strategy much earlier when the market was not ready. It took a long road to convince customers, employees, vendors and suppliers that data can be collected faster and efficiently through connected sensors and devices, leading the company toward sustainable decisions.

**External Barriers-**

Network connectivity is a problem faced by many local companies shipping products globally; as the global reach increases, firms in Sweden are taking a sustainable approach to packaging and tracking products. Due to different networks being used in various places globally, it becomes hard to keep smooth data transfer and IoT device integration. Global coverage is an issue in connecting things. Companies can not adopt technology even if they want it instantly; for example, when using computer vision, the USA has it much easier than Europe due to GDPR. That is why, before adopting new tech. Companies have to research what kind of legislation and government rules are there in certain countries. Skilled labours are available as more younger generations are graduating, but it is challenging with the change management to transform the mindset of workers towards a complete digitalised working environment.

**Benefits-**

Many functionalities, benefits, and task execution can be done in road transportation using IoT devices. Small devices can track; measure the distance and shapes of goods; reduce the risk of theft; can measure temperatures. All these devices can be installed in the transport or inside the containers, in or on boxes of products. In the case of Scania, connected vehicles also fall under IoT with mobile devices and telecommunication. Scania gets data on fuel consumption and Co2 emission; they can measure the vehicle load and goods carried to determine the total emission produced by that shipment. It is an exciting field of research because not many companies have measured emissions, comparing the cargo and the vehicle. The respondent said that during his
time in Scania six years ago, RFID was costly, but now the availability of connectivity of a unit to a container is as cheap as 1 SEK per month as a subscription. IoT is beneficial for humanitarian logistics; the military can track medicines sent to a disputed or a crisis place without the risk of theft and loss. This technology has much potential to evolve in the future as it can predict supply chain disruption and determine where to place stock, transport and resources in response to operating conditions to maximise efficiency and responsiveness.

4.2.6 Avia & Co. / CISL

Internal Barriers-
The respondent started by pointing out the right fit of technology that matches the capacity, capability, perspective and culture of adopting IoT and its solutions. Managers must assess and be made aware of the internal changes required to adopt technology in a company. Often these technologies come with interfaces or requirements that are not tailored to the company making small and medium-sized enterprises reluctant to shift towards IoT. Transport companies often end up not using tech-related items to optimise their workforce due to a lack of knowledge; no one is educating the board of the company regarding the advantages of technology. This lack of knowledge among key leadership personnel within a company leads to not carrying out an investment plan for IoT infrastructure because they do not recognise the potential this technology has for the company.

External Barriers-
IoT solutions are provided by multiple communication service providers; truck companies often end up with numerous devices and solutions to meet customers' needs. Using solutions and devices from various sources gives rise to data privacy, security and compatibility issues. Certain providers might have strict protocols and multiple security layers denying data integration from other operators due to data policy, leading to the company using various disconnected devices, increasing the data processing time.

Benefits-
Investing in IoT devices will also push for better waste management and rising sustainable production for electronic devices with increasing sustainable product demand. The data collected
through IoT will increase the ability of businesses to come up with complex models that determine the likelihood of disasters, like hurricanes, affecting business operations. Regarding the lack of skilled labour, the respondent added,

“There is a vast pool of skilled labour and abundant fresh graduates waiting for jobs in IT sectors in developing nations.”

The technology can prevent future supply chain disruption and also will be able to help companies locally source materials rather than being dependent on global resources when faced with a worldwide crisis.

4.2.7 IIIEE

Internal Barriers-
IoT devices often have security and privacy breach problems. If companies can trace products, they can also track employees working in warehouses and measure their efficiency. An example provided by the respondent is that warehouses of a specific delivery company can track their warehouse employees and measure their productivity levels. This gives the company more control over individual performance by understanding an individual's work pattern. However, when looking at the data from above, it is primarily aggregate numbers, where the ethical consideration is frequently removed for the optimisation of logistics.

Cost is a significant barrier for many because of whether the companies can recover the additional costs from their customers. Buyers at the end of it are usually interested in the services provided by the benefits of data. The question is for the individual transport companies to make sense of bearing these additional costs. Using electricity or energy for operating devices impacts the cost, often a barrier for companies.

External Barriers-
The first challenge that many transport companies, logistics firms and suppliers encounter is data collection and sharing. Many suppliers up and downstream using transport, whether as first or the last mile, often do not know how to collect data or even if they could, they will not share data
for various reasons. Many companies are unwilling to connect seamlessly with external stakeholders due to trust, confidentiality, and proprietary data. Even willing to share data, companies face challenges on compatibility, different suppliers in the supply chain using different software. Approaching solutions providers might help suppliers build integration and infrastructure according to their requirements. One challenge is the environmental factor, which plays a more prominent role in sustainable transport because of the supply chain's CO2, NOx, sulphur and various other emissions. There are often tradeoffs regarding social and environmental factors in the transport sectors, making it harder for a sustainable supply chain.

The traceability of products and assets might involve legal concerns and privacy issues. Many companies would not want their suppliers to be known as a piece of public information; competition or buyers would trace the back to the source to procure it directly from the first supplier in the chain, eliminating other stakeholders. When companies use IoT or technologies as such regarding sharing data, they often do not have an idea of the whole ecosystem and the external threats that exist regarding security. Since data is transferred among multiple suppliers, there is often a lack of responsible individuals or companies and diffusion of responsibility is usually generated.

From a sustainability standpoint, common pool resources and limited raw material sourcing are the biggest challenges. Regarding minerals in technology devices, conflict minerals, such as cobalt or lithium, are becoming a more significant issue. Often companies use all the buzzwords regarding sustainability, but in reality, there is a gap in the approach when it is about providing sustainable products and being sustainable. At the same time, we are also observing legislation taking place for tighter due diligence requirements and human rights impact. Nevertheless, the respondent pointed out the scalability of IoT. The unknown facts of the number of devices needed are sourced sustainably or not, what happens to those devices afterwards, and their circularity.

Implementing sustainability in supply chain management for traditional transport companies is often not logical. Companies and their managers think that if they emphasise sustainability, they
might have to carry out extensive reforms and create new supplier relationships, and many might eventually lose their job in the process.

**Benefits**
The respondent points out the redundancy reduction by efficiently utilising information technology. “Using Information technology can, first of all, reduce a lot of redundancy or have more efficient setting of different transport, half empty and unnecessary transport can be removed by scheduling better with the use of IoT and digital twins.” IoT enables transport companies to reduce or remove the usage of unnecessary half-empty transport by scheduling, optimising delivery distribution and covering a broader range in a shorter period. Transport companies can also create a digital twin, which increases the possibility of tracking the status of transport and products through the supply chain, whether on route or in a warehouse, which can also enable them to decide on deliveries leading to less carbon emission strategically. Digital solutions play the enabler role of tracing products from the first mile to ensure an ethical and sustainable approach has been taken to ensure a reduction in emissions. Collecting data through IoT gives companies the advantage of tracing and measuring CO2 emissions from their sources. Many large companies in food and beverage or fast-moving consumer goods industries are working towards creating digital twins of their entire supply chain, where they will be able to trace the up and downstream flow of the supply chain. The topic of sustainable supply chain management through the integration of IoT is a compelling topic, according to the respondent, as this topic highlights the synergies among various elements while there are existing trade-offs among the issue.

Supply chain disruption can be avoided in specific areas through the usage of connected devices because there are unseen human errors which cause waves and bullwhip effects. IoT can help suppliers with tools to make strategic decisions on whether there is an actual shortage of goods in the market or if it is just random buying behaviour that causes deficits in the stores. The data from IoT can point to where the bottlenecks are for the suppliers. Supply chain managers often tend to optimise the supply chain till the last bit, but maybe that last bit is not worth it. Rather than keeping low inventory and operating just in time, it is better to keep inventory in stock. So
that there is still a small amount of buffer to deal with unforeseen circumstances like an excess shock to the system.

### 4.2.8 Electrolux

**Internal Barriers**

Control tower systems will inform companies where the containers and trucks are, along with geopositioning them for exact location. All this does is give customers the location of their products and how long it will take to reach them. Employees in the company need to have the knowledge and the skillset to use the data collected to provide a result; otherwise, all the data accumulated is useless if no one in the company knows how to utilise them or for which reason they need them. Even though RFID is cheap, what will the information lead to, and what are the benefits of those actions? These fundamental questions are necessarily not straightforward. Scalability for a company is useless until it can utilise the data. The employees must be mature enough within the company to use the data for the company's benefit.

**Externals Barriers**

According to the respondent, “*For the transport industry to operate sustainably, first, they need to be green and to go green, they need to adapt to technology and go digital.*” Without support from suppliers and partners, utilising the data efficiently to have a sustainable transport system becomes pretty impossible. When embedding technological devices for transport companies, investment is significant, and the cost of an electric truck with the latest technical features is three to four times higher than a standard diesel truck unless these small companies get a particular contract with transport suppliers to use their vehicles or obtain funds from other suppliers to purchase green transport systems or vehicles. Many companies do not know where to start and how to act if no demands are driving them to adopt IoT. Power dynamics operate differently in the supply chain because the transport company's downstream and upstream tiers have different challenges. The respondent repeatedly pointed out that cost, incentive and demand drive the technology to be in use by transport companies. When there are security challenges, leakage or any mistreatment of data, the company transmitting in the first place should be held accountable rather than collectively taking responsibility for any data leak.
Device hacking can be constant, and even so, expensive cargoes are more at risk of cyber attacks, but companies transporting such shipments have the infrastructure to prevent an attack. In that case, cyber threat is not a challenge these days from the respondent's perspective. Transport companies in Sweden faced challenges with implementing tracking devices at the beginning. When transport companies tried to embed sensors to track the carrier, unions and drivers came together and resisted. After years of negotiation, that has been reduced, and the drivers do not hesitate anymore; for example, airmee, budbee let customers track products and vehicles' whereabouts. The potential benefits of tracking transport outweigh the challenges a company faces with drivers or other employees. The future of Industrial IoT will keep growing and, at the same time, will expand more towards the consumer sectors. The companies that could collect data through control towers and controlled data and information regarding transportation during supply chain disruption had a competitive advantage over others during covid.

4.3 Summary
The Empirical result collected through interviews connects to the barriers introduced in the literature review. The respondents have highlighted similar barriers from their context and added new barriers to why adopting IoT devices for a sustainable supply chain in the transport industry is challenging. They have also highlighted the importance of embedding IoT in everyday operations and the advantages that come with IoT. In this part, the internal and external barriers along with benefits will be summarised briefly while discussing similar results through interviews.

Internal Barriers
The main internal barrier would be the mindset of traditional transport companies and their ability to learn and adapt to the IoT ecosystem. Respondents B, C and F have agreed that management is often reluctant to invest in the infrastructure as they cannot foresee a possible return on investment in the short term or are hesitant due to a lack of understanding of technology and innovation. Nevertheless, on the other hand, respondent A has highlighted that it is rather a lack of department collaboration which is an internal barrier; respondent D pointed out it is a corporate culture problem. Respondents C and H argue that employees in the company
should know about utilising the data collected through IoT to have any outcome or also having competent, skilled labour internally is a factor in not being able to transition to IoT implementation. According to respondent B, D, E, privacy is a challenge for employees in transport companies as they fear being micromanaged through tracking, but only respondent E and H has agreed upon that the challenge of privacy goes beyond just employees being tracked rather it also involves customers. Managing a significant amount of data requires an intensive understanding of the output it can produce; if not utilised and analysed correctly, a company will never find investment in IoT a feasible option. The respondent at Scania argued that departments within an organisation must collaborate to understand each other's operations by sharing technology and knowledge to achieve sustainability. Respondents A and H have also mentioned that the most important data collected through IoT is being sat idle and requires knowledgable labour within the organisation to utilise them and provide a result leading to sustainable transport solutions. Respondents E and G have mentioned significant investment challenges due to internal demand for such tracking services; the costs of implementing individual sensors and interconnected devices are often too high for some organisations.

*External Barriers*

Investment in infrastructure from suppliers in different tiers is an essential external barrier. Suppose they do not want to integrate IoT into their transportation. In that case, the transport companies will not be able to provide visibility and control of resources throughout the whole supply chain, as argued by Scania’s respondent. Respondent B has also pointed out that it is a significant challenge with Investment to ensure that all the stakeholders in the supply chain adopt the IoT ecosystem as often they do not consider the future ROI and becomes hesitant by the cost of implementing the infrastructure. Tracing sustainable sourcing and transporting becomes an issue for organisations involved downstream. The lack of available skilled labour is an external barrier for developed countries, even though respondent F has pointed out that skilled labour in developing nations is readily available. Also, the availability and cost of IoT solutions that are not tailored to a company's specific requirements are an issue. The high cost of green trucks and the IoT ecosystem is often three times higher than those of traditional diesel trucks, for which many companies still do not get the funding or support from external stakeholders to pursue such technology in their company. Government policies might differ according to respondents E and
D across the country during data transfer. This is an external barrier for many transport companies operating cross borders as they must comply with different data protection rules and regulations. Due to the requirement of complex collaboration among multiple stakeholders, transport companies might face legal and accountability challenges when data is transferred among numerous suppliers. Respondents argued that due to the high societal pressure of fast purchasing, it becomes hard for transport companies to comply with sustainable standards when the demand for fast deliveries outweighs anything else. Scalability and seamless integration are challenges due to network complexity across the country as there are different stakeholders with different policies and legislation in place on the usage of networks to transfer data. Strict protocols and multiple security layers make it challenging and expensive for transport companies, according to respondents E and F. On the other hand, respondent G argues that partners within the supply chain often blocks the integration of IoT devices intentionally in fear of competitor stealing vital information on sources of supply. Respondent G has highlighted a significant challenge which many respondents have failed to mention is the challenge of minerals being extracted from conflict areas which are being used for the production of IoT devices.

**Benefits**

Various benefits have been identified in the empirical results, highlighting the importance of IoT for a transport company to achieve a sustainable supply chain. Respondents often shared the standard view of carbon emission reduction with actual data from Scania of 15% reduction in emission through the use of IoT devices and IT departments utilising those data efficiently. Fleet management, time and delivery optimisation are among the essential benefits. Predictions of disaster and the ability to mitigate loss faster through data sharing, collaboration and finding alternate solutions are among many benefits mentioned by the respondents. Increasing cooperation between suppliers, partners and other stakeholders is often achieved through IoT, which provides economic value and benefits to transport companies.
5. Analysis and Discussion

This chapter comprehensively analyses previous research and empirical results. The chapter follows the same structure as the empirical results chapter; but it is only divided into two sections based on Internal and External barriers. The sections discuss the barriers and suggest how transport companies can face and overcome challenges.

5.1 External Barriers

Empirical results show that almost all respondents have agreed upon a few external barriers that underline the issue in the research question. The barriers include resources, security, investment, infrastructure, integration, legal, accountability, and lack of skilled labour in adopting IoT for road transportation. Even though the return on investment in previous research has often been considered an internal barrier, few respondents agreed on the influence external stakeholders have on the return on investment and view it as a part of the external challenge. Kamble et al. (2019) and Whitmore, Agarwal and Da Xu (2014) have specifically mentioned these barriers in their paper as the most dominant factors of why businesses are reluctant to face these challenges in adopting IoT.

5.1.1 Facing and Overcoming External Barriers

Resource Barrier

Limited resources are an agreed-upon barrier by all respondents. However, not everyone has shed information on the limited resources. However, those who have considered resource barriers have mentioned that the scalability of the IoT will be challenged due to limited resources sourced from conflict areas with volatile supplies. As Barume et al. (2016) and Blumenthal and Diamond (2022) discussed, 3TG minerals are often extracted from conflict zones, which are necessary to produce IoT devices. IoT device manufacturers must follow the regulations and adopt certification to procure conflict-free minerals sustainably. It usually leads to an increase in price for IoT devices. Resources are finite, and there will be no way to reproduce rare earth minerals since Nižetić et al. (2020) mentioned the amount of e-waste is so vast worldwide that 6kg of waste annually is being made per habitant, of which only 20% is being recycled. The only
temporary solution is to reduce the waste by finding ways to recycle the e-waste. The number increases from 20%, providing a temporary solution to the resource barrier with the advantage of emphasising a circular economy. An organisation can gain a sustainable competitive advantage through well-organised, valuable, rare, inimitable and non-substitutional resources.

**Infrastructure, Investment, and return on Investment Barrier**

Through the interviews and primary data collection, one of the most correlated barriers encountered was the Infrastructure, Investment and return on investment barrier. It is because transport companies have to get funding first to invest in the IoT ecosystem. Budgets can be approved internally, as argued by some respondents. However, respondent H would say that other stakeholders must have agreed upon investment in a complete IoT ecosystem that interconnects all the suppliers upstream and downstream to make it effective. Altuntaş Vural et al. (2020) argues the same in their research, stating that different actors involved in the supply chain have to invest in the similar interconnected infrastructure of IoT devices to benefit the full potential of IoT throughout the supply chain. The internet of things' functionality connects one device to another to communicate without human involvement. That can only happen when all the suppliers agree to share data and have open access infrastructure to their devices for their stakeholders. Padyab et al. (2019) highlighted that the involvement of relevant stakeholders who fosters innovation could prepare and increase the process of IoT adoption. On the contrary, Kamble et al. (2019) mentioned in their research on IoT adoption in the food retail supply chain that successful implementation of IoT is challenging due to stakeholders using their separate legacy systems. Which has been a significant hurdle in the food retail supply chain to integrate all the suppliers into an integrated platform. Similar challenges exist throughout the transport industry as traditional transport companies are often reluctant to adopt new integrated platforms and have an existing legacy system, which they might find expensive to change.

External stakeholders and network actors need to create the demand for IoT through industrial operations and investment. If the external stakeholders show no demand or interest, the transport companies often question why they should invest in such infrastructure and what value this adds to the organisation. As Al-Talib et al. (2020) mentioned, the traditional supply chain and its infrastructure is vulnerable and does not hold in the VUCA context. Investment in the
infrastructure will allow businesses to be innovative, look at new ways, and rethink existing processes and networks. This will create new forms of value for stakeholders, old or new, so they might also invest in IoT infrastructure, increasing the demand for supply chain players to adopt this technology. Telecommunication companies such as Telia and Tele2 have the resources, investment and infrastructure to provide sustainable value analysis tools (SVAT)\(^8\) to transport companies. To measure the importance of value added by IoT in their supply chain, the data is then appropriately represented to external stakeholders and will aid in driving demand and even get funding for infrastructure.

Scania has been a leader in the heavy truck transport industry, providing interconnected fleet management solutions to its customers. Utilising Scania’s innovative tech embedded trucks gives operating transport companies in the supply chain of given industry transparency, flexibility, control and collaboration opportunities. Scania has made sustainable IoT embedded vehicles through a partnership with Telenor, Ericsson, Northvolt and many other big and small companies. They have convinced their partners to invest in IoT, and electrification of heavy-duty vehicles to achieve net-zero carbon emission by 2040 (Scania Group, 2022). Transport companies without IoT infrastructure can benefit from a shared cross-industry investment in building an ecosystem to mitigate the lack of connectivity barriers and improve communication within the supply chain (Altuntaş Vural et al., 2020). Since respondent H already mentioned that it is hard to invest in infrastructure without demand driving the investment, small transport organisations can instead invest a minimum amount to purchase IoT devices and solutions from service-providing companies. For the investment to take place, organisational support is also required internally from managers and employees, as mentioned by Carcay et al. (2018). Though these devices from communication service providers (CSP) will not provide as much functionality as the Scania truck with built-in specialised sensors. Scania’s IoT is not just used for tracking; among many other things, it produces the LCA of the truck by measuring its engine and overall performance. There is similar functionality among the service providers and Scania’s IoT, like temperature control, carbon emission reading, the truck's weight, driving pattern, tracking, inventory and fleet management.

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8 SVAT is particularly relevant to the product development process, especially when multiple contributors come together to evaluate effective and efficient value creation.
The knowledge of organisation leaders is another reason why the initiative of adopting change is often ignored, which is also what Carcay et al. (2018) and (Venkatesh, 2003) argue in their paper. Meyer, Gracht and Hartmann (2021) argue that the rapid increase in road freight transport for faster delivery both upstream and downstream of a supply chain makes managers focus narrowly on the efficiency of more immediate delivery and cost reduction. For traditional transport companies, it is not viable to create a department focusing only on implementing IoT; instead, a holistic approach to adapting IoT from communication service providers seems more cost-effective. Companies like Telia and Tele2 are providing sustainable IoT solutions that fill the gap within the transport company. The investment is a bare minimum, and the IoT setup is usually included with guidance from the service providers.

The benefits of Telia and Tele2 IoT sensors and services are that they operate with low energy and provide years of service before it is no longer functional. According to respondent B2, the Lpwa network used by their devices gives them a longer life span as they consume less energy to operate. The same devices are also supplied by Tele2, which have a low setup cost and consume less energy making them sustainable IoT devices, according to the respondent. These services include dashboards, real-time map generation, analytics for managers through applications, built-in firewalls and routing for security. All these setups being available from telecom companies on a subscription basis makes it easier for traditional transport companies to adapt to IoT technology and make it worthwhile to achieve sustainability in their supply chain. The investment is relatively lower than building one ground-up interconnected infrastructure in the company, and also 24/7 support is given with continuous connectivity across borders.

Privacy and Security Issues

In the UTAUT constructs, the privacy issue is a part of social influence; significant privacy concerns, according to Carcary et al. (2018) involve the challenges of uncontrolled data generation and diffusion, inadequate authentication, preservation of anonymity and risks pertaining to sensitive data. The interviews and studies of previous research show a correlation between privacy and security barriers. For that reason in this chapter, they are discussed together in this section. According to respondent E, employees had little resistance when Scania first tried
implementing IoT technology in their trucks. Employees were concerned about being in constant observation, which can give the managers ability to micromanage their working environment. But through tracking, safety measurements can be taken to ensure drivers' well-being, the well-being of the surrounding pedestrian, and the products onboard (Scania Group, 2019). The factors regarding social, economic and environmental benefits that an interconnected fleet brings to Scania triumph those of privacy issues. Because connected vehicles give Scania the data, they require to research and develop a more advanced fleet of eco-designed electronic trucks. Such as Tesla is considered more of a data-driven car manufacturing company for consumers, and Scania is considered the same for businesses. Even though these data might include the transport drivers' personal information, driving patterns and often end customers' home addresses. With multiple advanced layers of security and firewalls, data integrity is ensured by the company from any possibility of privacy risk to customers and employees. Then again, such concerns on data management arise among individuals involved in the process in terms of who owns the data where multiple actors are connected to a system (Carcary et al., 2018).

Nevertheless, Ding et al. (2020) argue that connected vehicles are most vulnerable to attack; since there are multiple layers in the IoT, the attack can come from any of the layers, such as the sensing layer, networking layer or service layer. Data privacy risk leads to information disclosure through which user preference and schedule can be tracked. Drivers and customers have often shown concerns over the risk of tracking data and privacy violations in the logistics process (Ding et al., 2020). Even transport companies are concerned over data being stolen by competitors. This can happen through attacking layers, and the most common privacy problem is shared delivery information due to the nature of resource sharing through the open access nature of connected vehicles (Ding et al., 2020; Wang et al., 2019).

In prior research carried out by Kamble et al. (2019), they categorised external security risks and challenges in IoT implementation involving data encryption, internet connectivity, software protection and authorisation. A gap exists in Kamble et al. (2019) research and also in the results in this thesis where internal security challenges are not identified. However, Alsamari and Anwar (2016), in their paper, identifies internal security challenges for the health care industry, which might be also applicable to the transport industry. They mentioned that the first challenge is
managing the credentials and controlling access to applications and patients’ confidential information. They have discussed that the access of networks to employees should be authenticated as there are possibilities of data tampering and providing digital credentials for verification purposes.

**Compatibility Issue**

In table 2, Federal Transit Administration (FTA) 2017 has mentioned the standards of IoT devices for data transfer over network devices; this will require the devices to be able to communicate with one another. Boyeun Lee et al. (2019) have also mentioned the complexity involved with interconnected devices in the supply chain due to the wide range of connected products, multiple layers and types of partners. Devices installed in a Scania truck will not be able to communicate with devices onboard another company truck unless there is a technical collaboration among competitors or partners. It already reduces the ability to have an interconnected ecosystem and continuous data transfer. This happens because companies do not want their competitors to get hold of sensitive information, but it also restricts the main functionality of IoT. However, to ensure a global interconnection of IoT devices, Carcary et al. (2018) argue in the facilitating conditions of the UTAUT construct that large vendors, rather than standardising IoT as a closed proprietary product around them, should invest in making IoT devices universally standard.

The most significant issue on compatibility is based on the lack of collaboration among suppliers, but to build a connected infrastructure requires a collaborative investment which is often time-consuming and expensive, as discussed above in the investment barrier section. Even though respondent E has said that global coverage is an issue for connected devices, respondent B and C has assured the possibility of eliminating the device connection problem if more collaboration is done among network providers globally. SME transport companies’ challenges can be mitigated by getting devices and services provided by Telia, Tele2 and other communication service-providing companies because their international collaboration with other companies allows for faster data transfer and robust connection.
Apart from Network and hardware compatibility, software compatibility can be another factor, as mentioned by respondent G. Establishing compatibility and similar protocols among different industrial software will allow gateways to generate signals for sensors to communicate over networks; this creates bidirectional communication among sensors and the network (FTA, 2017). Respondent A has mentioned that by investing and increasing the software's capability, any company like Scania can achieve to reduce 15% of carbon emissions throughout the year. A company proportionate to Scania will achieve unfathomable sustainable development through investment in software. Even if efficient collaboration exists in software development, it is often faced with data policy barriers in different countries. A perfect example of respondent E on computer vision is an AI that enables computers and systems to derive meaningful information from digital images, videos and other visual inputs — and takes actions or makes recommendations based on that information (IBM, 2022). Even though the work on this AI is in continuous development worldwide, it is no exemption in Europe due to GDPR, so respondent E points out the possible use of this is different in Europe compared to the USA.

Respondent F stated another issue: when companies deliberately compromise on compatibility and reliable data transfer among the whole supply chain. Action like this is usually carried out to protect information vulnerable to the company; from their perspective, raw materials and labour information sources could leak to competitors. Even the suppliers or companies in the supply chain might omit intermediaries and directly supply or buy from sources. On the other hand, Lee and Whang (2000) pointed out that sharing information among the supply chain can eliminate the bullwhip effect. The typical scheme mentioned by Lee and Whang (2000) involves sharing information on inventory level, sales data, sales forecast, order status, and production/delivery status both upstream and downstream. However, while protecting proprietary information or properties by fragmenting IoT through restricted interconnection capability, the organisations carrying out such action might find themselves reducing the value proposition for future IoT investment (Carcary et al., 2018).

**Legal/Accountability Barrier**

Roes et al. (2015) mentioned that to increase the scalability of IoT, governments and private organisations must find a way to create a collaborative partnership for the infrastructure to grow
and be developed. The reality, on the other hand, is far from different. In 2010 many countries, including Australia, Brazil, China, India and Turkey, introduced or enforced rules that prohibited or restricted devices from being operated by overseas operators for free-roaming (Telia, 2021). Also, in US and Canada, many operators restricted their partners from having devices freely roaming within the country without local registration. This is an issue for Scania and transport companies operating overseas where their parent company subscribes to IoT infrastructure provided by companies like Telia and Tele2. This will require transport companies to get registered in local networks of foreign countries to ensure compliance with the regulatory bodies and follow partners' rules on permanent free roaming. Ghaffari, Delgosha and Abdolvand (2014) have highlighted the constraint involved due to political and regulation differences in getting the data out of countries with strict rules. Data sovereignty also creates a legal boundary on how transport companies collect and store data; one perfect example is GDPR in the EU. But in Telia's (2021) report, they argued that these restrictions often invite innovative ideas on IoT architecture and how to use the platform to install compliance on data not being able to manage in different countries inappropriately.

However, this research aligns with the critical findings Kamble et al. (2019) mentioned in their paper regarding how judicial laws should provide guidance. Without proper structure and regulations in place, it is hard for over-the-road transport companies to understand the laws of the country they are operating in clearly. What is their efficient use of energy, network capacity, and network usage clearly define the restrictions on sensitive frequency bands (Kamble et al., 2019)? As stated in the paper, their solution is for the country's government to collaborate with organisations regarding changing dynamics and promote and support technological innovations and solutions. Respondents A, B and C has mentioned the cooperation or collaboration among the government and organisation. But there is a gap in answering how those collaborations should take place in this thesis.

_Lack of skilled Labour_
American Journal of Transportation - Ajot (2022) have mentioned that one of the potential reason why infrastructure fails to develop after a certain extent is because of the shortage of skilled labour available in the market. This shortage of capable workforce can be problematic for
a developed country and can be mitigated through training. Since the developed countries has a low growth rate and even a declining population in some instances, training is an expensive project for companies in those countries to teach employees new skills for new tech to keep up with the competitive market. That is why Sharma et al. (2020) have written one point about the barrier to return on investment: many companies find training current employees costly and unnecessary due to increasing demand and a shortage of proficient workforce. Respondent C points out that companies usually fail to realise the need for IoT because of the lack of internal skilled labour. Even though there is a growing demand for tracking and tracing assets through the supply chain, the company might never use these technologies if the employees working within the company do not realise the potential benefits. Respondent E, on the other hand, said that there is an increasing number of skilled labour available daily due to new students graduating. For developed countries getting skilled labour is very expensive, and hiring fresh graduates and bringing them up to speed with training is costly, whereas the developing nations have a huge benefit with a vast pool of graduates and skilled labour readily available and have an actual low training cost. On the other hand, Končar et al. (2020), argues that there is a lack of skilled and trained labours in the supply chain, especially in developing and transitioning nations.

A report published by Telia in 2017 regarding connected things (Dahlberg et al., 2017) states that the OECD countries' average age of workforce participants has gone from 37 to 42 between 1980 and 2015. Even though the percentage has risen, the cost of retaining employees has skyrocketed by 25%. While the retirement rate is increasing, the new generation's skill gap is also becoming a problem. The solution to such a problem should be to invest more in training, hire a cheap foreign workforce, and retain them.

5.2 Facing and Overcoming Internal Barriers

The internal obstacles to implementing IoT for a sustainable supply chain are the inability to accept technology due to the traditional organisational mindset and the failure to collaborate among different departments and managers. Respondent has pointed out that the collaboration among departments within Scania needs to be more flexible. As many departments have few ideas about the regular operations conducted by their colleagues in various departments, the sustainable development department might not have proper knowledge about the IT department.
Collaboration among departments can create synergies leading to proactive risk management, which is essential to face disruptions. Carcary et al. (2018) mention in their paper that it is also the lack of senior management knowledge, commitment, support and inadequate employee technological skills are also some major internal factors in IoT implementation. Al-Talib et al. (2020), Bui et al. (2021), and Robertson (2021) have argued that the best way to avoid uncertainties and also gain a competitive advantage is to collaborate among all stakeholders and network actors. Collaboration among departments will make it easier and more efficient to utilise the data; as mentioned by respondent H that companies are collecting data more than ever, but whether they will be able to achieve something valuable is a significant challenge. As the scalability of IoT devices is increasing, communication among internal departments needs to be agile and precise to get the best of the collected data. This can also lead to a more sustainable approach to embedding devices in trucks as different departments within the organisation can use the data to collaborate on sustainable business practices ensuring privacy and security in terms of social factors to all stakeholders. So the critical argument remains that it is imperative to communicate and disperse knowledge within the organisation among different departments.

According to respondent A, Scania has a data centre where valuable data collection occurs without being used correctly. Also, respondent H mentioned that an organisation could manage all the data it wants, and it will still be useless until or unless they know precisely what information they need to form the data. This relates to what Chen, Chen, and Yang (2021) have mentioned: socio-technical challenges arise if data sharing among supply chain partners is not occurring, while inaccuracy and inefficiency will appear in the supply chain if the information is one-directional. Granting access to the data league based on ranking might be a barrier. It is something Alsamari and Anwar (2016) argue, personnel working need authorisation for full access to maintain privacy and security. Which is an internal barrier in every aspect of seamless data integration and cross-department collaboration for road transport companies or any company establishing IoT in their organisation. Instead, giving access to all departments and partners will solve the collaboration issues and make the work culture more transparent. According to de Vass, Shee and Miah (2021), full access to data will enable organisations to close the gaps and transit to Industry 4.0. Where intelligent and connected objects will provide road transport companies with faster monitoring, control, optimisation, and autonomous
capability. Departments can use full access to all the data for the company's benefit by making robust collective decisions regarding environmental and compliance risks; they can also implement the circular design. Take the maintenance department as an example; they can 3D print parts of a truck if they have full access to the vehicle's health data; this will reduce time, improve routine maintenance and be more cost-effective.
6. Conclusion

In this chapter, the author presents the conclusion of the study based in relation to the research aim and questions, based on the study analysis and discussion. Finally, the thesis presents shortcomings and the proposal for further research in the conclusion.

The supply chain has so far evolved incrementally by adding elements with not much consciousness of the surrounding impact it has on society and the environment. Using technology, supply chain managers can take innovative approaches to ensure more conscious supply chain design. With conscious design, supply chain managers can take a holistic approach by providing value to stakeholders while ensuring that resources are not compromised for future generations. The problem is not just preserving limited resources but also reducing carbon emissions, pollution and safety for society and the environment (Shen et al., 2011). Due to globalisation, key challenges to the modern supply chain are the supply chain design and the spread of resources worldwide, which usually increases the lead time as supply chain managers depend on faster and cheaper transport.

The results that formed the part of the analysis and discussion answered the two research questions in the thesis:

RQ1: What barriers do road transportation companies face while integrating IoT to achieve Sustainable Supply Chain Management (SSCM)?
RQ2: How do road transport companies overcome the barriers?

This research goes in line with Kamble et al. (2019) paper, which mentioned the barriers faced by food retail supply chains in adapting to the internet of things. Even though these two pieces of research are carried on different industries, the barriers to adopting IoT in the supply chain are quite similar. One missing point from this thesis which Kamble et al. (2019) mentioned, is the high energy consumption of IoT devices. Based on the conceptual framework, the research has
shown the internal and external barriers to IoT adoption in road transport and the benefits of overcoming the barriers. Using UTAUT, originally presented by Venkatesh et al. (2003) and Carcary et al. (2018) research on four constructs of UTAUT, the thesis presents the barriers which try to answer the first question for the thesis. The second question is something previous research and interviews led up to in this paper, presenting the benefits and how to overcome the barriers of IoT through collaboration, cooperation and organisational support.

The study has identified the challenges transport companies as intermediaries are dealing with while trying to implement IoT in their supply chain. With multiple internal and external partners and stakeholders, these companies are continuously trying to push the boundaries of innovation through IoT implementation or operating traditionally. The complexity of technology being used to improve the supply chain by making it transparent, economical, environmentally friendly, secured and sustainable is something transport companies are dealing with regularly. Pressure for a sustainable approach toward the supply chain is increasing while the increasing demand for instant deliveries is becoming a parallel challenge for transport organisations. Managers involved in supply chain decisions have to make drastic choices to comply with policies and, at the same time, be efficient. The study highlights the barriers and provides solutions to current challenges transport companies face due to rapid technological changes, data policies over boundaries and global disruptions through climate crisis, wars and sanctions.

Overall, this thesis recommends overcoming barriers from the perspective and experience of individuals in the field of supply chain management. The study has practical implications as insights can help other transport companies address innovation and sustainability challenges. The benefits of adopting IoT have also been mentioned in the empirical results, and the data has been provided in isolation to observe better how each respondent from different backgrounds sees transport companies benefiting from integrating devices by overcoming barriers. Overcoming the obstacles and utilising the full potential of the IoT ecosystem can provide transport companies with visibility, flexibility, collaboration and control over their supply chain; this aligns with the four components mentioned by Al-Talib et al. (2020) in their paper.
6.1 Further Research

Many interconnected factors play a significant role in the transport companies' approach toward overcoming barriers to adopting innovative technology. Nevertheless, among all those factors, sustainable development should be the key focus, and it should not be just on theory to reduce CO2 emissions for transport companies. Transport companies can potentially increase global warming, acidification and resource consumption if they remain unchanged. Further research is required to determine the possible collaborative way to achieve net zero and reduce resource consumption throughout the whole supply chain for transport companies, as global warming is increasing faster than predicted. This can be done by figuring out how to invest more in technology and drive the demand to use it for the sustainable development of the supply chain. Digital transformation is required to be taken by all transport companies to benefit from modern vehicles being provided by manufacturers like Scania with integrated sensors and IoT services.

For communication service providers, it is essential to target SME transport companies and invest to guide them towards a sustainable approach to their supply chain. Furthermore, research on IoT, LCA and the circular approach is required to understand its impact on the environment because SCM analyses tend to consider one impact factor at a time, such as overall energy use in a system. The communication service providers can positively impact the growth of transport industries by giving them the tools required to mitigate specific barriers such as infrastructure, investment, skilled labour, security, scalability and privacy. Further quantitative research is needed to analyse the barriers' overall impact on the industry.

To highlight a few more barriers and setbacks to IoT implementation mentioned by Končar et al. (2020), which will open up the door to more research possibilities as an extension to this research. Končar et al. (2020) mentioned that similar to the existing barriers mentioned in this thesis, the different ones are as follows - Data analysis and comprehension, User Safety, new business model, Standardization and lack of awareness. Business model innovation is worth emphasising for further investigation. To make a company innovative and sustainable, transport companies might be required to reshape their business model entirely with radical investment and change management. A system thinking approach can be more beneficial than a
reductionism⁹ business approach that contains barriers. The depth of research on transportation adopting IoT technology from a global perspective and also in a particular industry perspective is missing in this thesis; rather, the thesis was conducted to understand the phenomenon of IoT adoption barriers for road transport companies by conducting interviews with individuals from various backgrounds. Maybe research on a single heavy truck and transporter manufacturing company or IoT service providing company might lead to finding more barriers and challenges companies face in transitioning to new technology such as IoT sensors and devices.

⁹ Systems thinking considers challenges within the entirety of the system and not just the section of the system where the challenge is found. The opposite of systems thinking is reductionism, with top-down command-and-control management. This reductionist approach is used in many organisations and supply chains in order to manage the complexity of these systems (Meadows, 2008).
7. References


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Appendix

Appendix 1 - Data from IoT

The uncertainty that characterises the modern business landscape poses significant challenges for the supply chain, factors such as political unrest, pandemic, sanctions, war and unstable foreign policies could drastically deteriorate businesses' ability to procure raw materials and practice stable supply chain operations. Events like these prevent a company from growing and creating value for its stakeholders. However, this research has highlighted that companies could use the data they can collect using IoT to their advantage and tailor their supply chain configurations to thrive in this context. According to Chevreux, Hu and Gandhi (2018)\(^\text{10}\), analytics is one of the technological innovations that businesses can use to enhance flexibility and resilience in their supply chain. This is only possible when a massive amount of data can be collected through the whole supply chain, and the data collection process can be optimised using IoT devices throughout the entire supply chain. According to Gartner (2018)\(^\text{11}\) analytics has been used in the industry as a catch-all phrase and can refer to various activities. However, the most commonly used varieties are descriptive, predictive, and prescriptive analytics. With the increasing use of IoT devices, all the data collected can be used for machine learning technology and improved algorithms. Predictive analytics is often used for business strategy for reacting to events. Prescriptive analytics builds on predictive analytics by recommending action in response to a potential future event. Transport companies can automate their supply plan using prescriptive analytics, understand potential risks and change, and optimise routing accordingly. Prescriptive analytics can also determine where to place stock in supply chain management and assess transport and resources to maximise efficiency and responsiveness. However, it is not widely utilised due to the technological limitations on data collection and simulation.


Appendix 2 - Interviews

Interview of Scania

The purpose of choosing Scania is to find the barriers transport companies face in integrating IoT devices into the supply chain. Instead, Scania gives first-hand data about the sustainable approach toward road transportation and how IoT is helping users of Scania trucks to achieve sustainability in their organisation transportation.

Interview Structure-

- Discussions about Interviewer, Interviewee and Scania
- Questions related to research questions in a more general perspective
- Questions related to research questions aimed toward the challenges faced by Scania
- Discussions about solutions

Interview Questions-

1. How can IoT bring sustainability in supply chain management?
2. How can Scania achieve sustainable supply chain management (SSCM) through integrating the Internet of things (IoT)?
3. What are the various types of IoT technologies implemented by Scania?
4. Can you explain sustainability from the context of Scania? What are the benefits and drawbacks of implementing SDGs in Scania?
5. What sustainable challenges does your company have to deal with?
6. What kind of sensors and IoT solutions are being used to face those challenges?
7. What potential opportunities are available for your company in IoT embedded sustainable supply chain for Industry 4.0 transformation?
8. What factors make enterprises adopt IoT in your opinion or from your experience?
9. What are the challenges of implementing IoT?
Interview of Telia

Telia, the largest telecommunication provider in Sweden, also provides IoT solutions and devices to logistics companies. They take pride in their asset management and tracking of products providing cutting-edge solutions to their clients.

Interview Structure -

- Started with the research topic, followed by an unstructured casual discussion.
- Questions were sent in advance, so Interviewees had an idea about the type of questions they had to answer.
- Relevant questions were asked and discussed.

Interview Questions -

1. What are the challenges to adopting IoT for your clients in the transportation industry?
2. How can businesses achieve sustainable transportation of their goods through the use of Telia’s IoT devices and solutions?
3. How does Telia utilise the data collected from clients?
4. Does the security of data concern clients to a level which becomes a barrier for them to adapt IoT technology and services?
5. How many IoT devices and solutions your company provides, and how are they helping with efficiency in the supply chain for your clients?
6. What's Telia’s stand on e-waste?
7. How are IoT products and services developed, and what risks are identified during the development process?

Interview of Tele2

Tele2 is another telecommunication company in focus for this thesis; they also provide IoT connectivity and solution to multiple companies in various industries globally.

Interview Structure-
Discussions about Interviewer, Interviewee and Tele2
Questions related to research questions in a more general perspective
Questions related to research questions aimed toward the challenges faced by Tele2 and their clients
Discussions about solutions

**Interview Questions**-
1. Let’s start with IoT in Tele2, and how does it offer sustainable road transport measures to logistic firms?
2. Can you tell me some barriers or challenges to adopting IoT in road freight transport?
3. Discuss the barriers to (Limited resources, Investment, Infrastructure, Security, Privacy, Seamless Integration and Compatibility, Legal/ Accountability / Governance, ROI, Lack of skilled labour, and Scalability).
4. What is your perspective on IoT technology and the potential role it plays for the future of supply chain management?
5. What is tele2 stand on sustainable development?

**Interview of DHL, RISE, CISL, iiiee, Electrolux**

**Interview Structure**-
- Relevant questions were discussed through chat, and the respondent only replied to specific answers in the case of DHL.
- Discussions about Interviewer, Interviewee
- Questions related to research questions in a more general perspective
- Questions related to research questions aimed toward the challenges faced by road transport companies
- Discussions about solutions

**Interview Questions**-
1. Let’s start with IoT in transportation, and how does it offer sustainable road transport measures to logistic firms?
2. Can you tell me some barriers or challenges to adopting IoT in road freight transport?
3. Discuss the barriers to (Limited resources, Investment, Infrastructure, Security, Privacy, Seamless Integration and Compatibility, Legal/Accountability/Governance, ROI, Lack of skilled labour, and Scalability).

4. What is your perspective on IoT technology and the potential role it plays for the future of sustainable supply chain management?

5. Do you think IoT can help to prevent supply chain disruption or predict it before happening? Like Covid-19?

6. What are the benefits of using IoT devices for the road transportation industry?